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INDIAN SCIENTIFIC TRADITIONS

(Prof. K. N. Neelakantan Elayath Felicitation Volume)

Editor

DR. N. V. P. UNITHIRI



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PUBLISHER'S NOTE

The principal objective of the Publication Division of the University of Calicut is to publish textbooks and other research-oriented and socially relevant books at a reasonable price without compromising on quality of production. The reading public, comprising mainly students and teachers, with overwhelming enthusiasm, has received all the books brought out so far.

This book, *Indian Scientfic Traditions (Prof. K. N. Neelakantan Elayath Felicitation Volume)*, edited by Dr. N. V. P. Unithiri, is the nineteenth book in Calicut University Sanskrit Series. The Publication Division acknowledges its profound gratitude to the Vice Chancellor, Members of the Syndicate and Dr. N. V. P. Unithiri for their wholehearted co-operation in publishing this volume.

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INTRODUCTION

I have great pleasure to introduce the book, *Indian Scientfic Traditions,* in felicitation of my colleague, Prof. K. N. Neelakantan Elayath, who is retiring from the Department of Sanskrit, University of Calicut, on 31st March 2003. This is the nineteenth book in the Calicut University Sanskrit Series.

Sanskrit studies are generally confined only to Vedas, Itihāsas, Purāṇas, Kāvyas, Nāṭakas, Alaṅkāraśāstra, Vyākaraṇa, Darśanas and the like. It is not well known that Sanskrit has also a vast literature on scientific and technological subjects like astronomy and mathematics, architecture and engineering, medicine, chemistry and botany, music and dance, law and politics. Of course, studies of medicine (Āyurveda) and astronomy and mathematics (jyotiśśāstra and gaṇita) were included in the syllabi in ancient and medieval India. And now also the practice is continued. But they have not been in the main stream. The result is: Scientists are not aware of the presence of this abundant literature in Sanskrit, and the Sanskritists are not competent to study and impart it to the world of Scientists. So there should be a conscious effort on the part of both the Scientists and Sanskritists to sit together and explore all possibilities that this bulk of literature contains.

Now, not many studies on this literature have come out. *Founders of Science in Ancient India* by Satya Prakas, *A Concise History of Science in India* edited by D. N. Bose, S.N. Sen and B.V. Subbarayappa, *The Positive Sciences of Ancient Hindus* by B. N. Seal, *The History of Hindu Chemistry* by P. C. Ray, *The History of Hindu Mathematics* by

Datta and Sing, *Science and Society in Ancient India* by Debi Prasad Chattopadhyaya, *Science in the Vedas* by Hans Raj, *Science in the Vedas* by V. N. Sastri, *Positive Science in the Vedas* by D. D. Metha, *Technical Literature in Sanskrit* edited by S. Vekitasubramonia Iyer, *Scientfic Heritage of India* in two volumes (Mathematics and Āyurveda) edited by K. G. Poulose, *Indian Astronomy* by Subbarayappa et al, *Historical View of Hindu Astronomy* by J. Bently, *Hindu Astronomy* by W. Bernnand, *Algebra with Arithmetic and Mensuration from the Sancrit of Brahmagupta and Bhaskara* by H.T. Colebrooke, *The Science of the Śulba- A Study in Early Hindu Geometry* by B. Datta, *Ancient Indian Mathematics and Vedha* by L.V. Gurjar, *Astronomy and Mathematics in Kerala* by K.K. Raja, *A History of the Kerala School of Hindu Astronomy* by K.V. Sarma, *Observational Astronomy in India* by K. V. Sarma, *A Critical Study of the Ancient Hindu Astronomy in the Light and Language of the Modern* by D. A. Somayaji, *The Elements of Plane Geometry in 48 Propositions from the Sanskrit Text of Aryabhata* by Y. Sarkar, *The History of Ancient Indian Mathematics* by C. N. Srinivas Iyengar, *An Encyclopedia of Hindu Architecture* by P. K. Acharya, *Indian Architecture* (three volumes) by M. A. Ananthalwar and A.Rea, *Elements of Hindu Iconography* (two volumes) by T. A. Gopinatha Rao, *Indian Architecture* (two volumes) by Percy Brown, *An Architectural Survey of Temples of Kerala* by K.V. Soundararajan, *Vāstuvidyāpraveśikā - A Text book of Vāstuvidyā* and *Vāstuvidhānadīpikā - Design in Vāstuvidyā,* both by Dr. Balagopal T. S. Prabhu and Dr. A. Achyuthan are among the prominent studies. Still there may be some more works in English and many in regional languages.

But, in the historiography of Science, no attempt was made so far, comparable to that done by Dr. Joseph Needham (1900-1995). His monumental project of SCC (*The Science and Civilisation in China*) has gained international reputation. Seventeen large volumes of this book have already been published. Some more volumes are under various stages of publication.

Taking Dr. Needham as a model, the late Prof. Debi Prasad

Chattopadhyaya launched a project to write a comprehensive *History of Science and Technology in Ancient India.* The first two volumes of the book had already been published in his lifetime. The third one, though very short, was also published posthumously. *History of Science, Philosophy and Culture in Indian Civilization* (in several volumes, 43 volumes have already been completed), the General Editor of which is D. P. Chattopadhyaya, is especially to be remembered in this connection.

Department of Sanskrit, University of Calicut, has, since its inception in 1977, been showing interest in this subject. In M.A; M. Phil. and Ph.D. Programmes of the Department, technical literature in Sanskrit has also been included. Two National Seminars were organized by the Department, one on 1- 4 July, 2000 with the financial assistance of the Ministry of Human Resource Development, Government of India, and another on 5-6 November, 2002, with the financial assistance of Rashtriya Sanskrit Vidyapitha, Tirupati (Deemed University). We have now decided to bring out a collection of papers, most of which were originally presented in the above mentioned seminars.

When we think about Science and Technology in ancient and medieval India, we have to clarify one point: To put in lucid terms, Science is a set of theories based on some axioms and Technology is the practical application of the said theories. The theories developed by Science can be verified and put to test under given conditions. And hence, experimentation and verification are essential elements of Science. This conventional concept of Science in Western tradition has query and investigation as its basis. In ancient and medieval India, as in the case of any other old civilizations of the world, many branches, which we now group under the head of pure sciences, were developed. Mathematics, Astronomy, Architecture, Medicine and Agriculture are some such subjects like Philosophy, Linguistics, Economics, Poetics, Polity, Statecraft, etc; which in the modern view come under cultural studies, have also been studied in ancient and medieval India. The common term used to denote all these branches of learning, whether it is Science, Arts or Humanities, is Śāstra in Indian tradition. Śāstra is

often defined as that which ordains. Sometimes it is defined as ajñātajñāpakam (i.e. a valid means of knowledge, which cannot be attained by any other means). These very definitions show the irrefutable and infallible nature of Śāstra. This naturally goes against the inquisitive tradition of the Western Science. But, one should not think that Indian tradition forbids one from questioning and striking a note of difference. Within a set frame, one is free to think, question and discuss things. This is one of the many internal contradictions, which ancient and medieval Indian tradition poses before us. It is because of this, we have a vast corpus of commentarial literature in Sanskrit. While interpreting the basic text in a novel way, every commentator strives hard to establish that his is the faithful interpretation. Along with this main stream of tradition, there always existed side streams and opposing currents, which kept the society progressing and the horizons of knowledge expanding. Of course, both these streams find their place in this book entitled "Indian Scientfic Traditions".

This book is divided into two parts. Since this volume is in felicitation of Prof. K. N. N. Elayath, Part A is intended to introduce him through his bio-data. Part B contains three sections. Section I has nine essays. The first of them, namely, "Scientific Methodology in Ancient India" by Prof. K. N. N. Elayath forms an introduction to all the articles included in this book. Remaining eight articles in this section are on astronomy and mathematics in ancient and medieval India. Of them the first two are of general nature. Prof. C. P. Narayanan has made an objective assessment of the development of Indian mathematics in which he points out what should we do to propagate the achievements, inherited from our ancestors. At the same time, he warns against the misguided and ill-advised propaganda that is going on in this field. Next article gives a general idea about the Kerala School of Indian astronomy and some prominent astronomers, based on K.V. Sarma's works. In the fourth paper, Dr. K. S. Subramanian Moosath examines the most famous work in this branch, *Āryabhaṭīya,* from the viewpoint of a modern mathematician. Dr. N. K. Sundareswaran, in his couple of articles, brings forth the salient features of Kelallūr Nīlakaṇṭha

Somayājī's two important works, namely, *Āryabhaṭīyabhāṣya* and *Tantrasaṅgraha.* Nīlakaṇṭha Somayājīs *Jyotirmīmāmsā* is a unique treatise, which reveals the scientfic methodology, followed by ancient and medieval Indian astronomers. *Sadratnamālā* of Kaṭattanāṭṭu Śaṅkara Varmā is a handbook that comprehensively deals with almost all the things treated by medieval Kerala mathematicians and astronomers. K.V. A. Rāma Poduvāl's *Gaṇitaprakāśikā* is a karaṇa text of considerable merit. These three treatises are analysed in the following three essays by Dr. K. Sekharan, Dr. N. V. P. Unithiri and Dr. E. Sreedharan.

Section II contains twelve articles pertaining to Āyurveda and allied Sciences. Dr. E. R. Ramabhai, in her essay, presents the definition, division, symptoms and treatment of the disease of blindness according to Vāgbhaṭa's *Aṣṭāṅgahṛdaya.* The content analysis and significance of the two basic texts of Āyurveda, namely, *Carakasamhitā* and *Suśrutasamhitā* are the subject matter of the following couple of papers written by Dr. A. P. Haridasan and Dr. M. I. George. V. G. Thanu's article is the next one, which summarises the contribution of Vaidyaratnam P. S. Warrier, who is considered as a doyen in the field of the renaissance of Āyurveda. Then we have an expositon of Elephantology in India by Dr. P. Narayanan Namboodiri, based on a few books in that branch of knowledge. Dr. N. V. P. Unithiri elabarately deals with Vṛkṣāyurveda portions of *Bṛhatsamhitā* and *Śārṅgadharasamhitā* in the next paper. Plant Science in *Śārṅgadharasamhitā* is separately analysed by Dr. C. Narayanan in his article. Dr. M. P. Kannan makes some observations on Indian Chemisty and Dr. K. Muthulekshmi gives an outline of the history of Indian chemistry. Next we have three articles on Physics. Dr. K. N. N. Elayath examines the structure and evolution of matter on the basis of the doctrines of satkāryavāda and ārambhavāda, put forward by Sāṅkhya and Vaiśeṣika systems of Philosophy. Dr. P. M. A. Rahiman deals with atomism in different systems of Indian Philosophy. In the last one of them, Dr. P. C. Muraleemadhavan invites our attention to some Vedic concepts on the sources of energy.

Section III is devoted for Architecture and Environmental Sciences.

Fifteen papers are included in this section. The first one is an in-depth study of indigenous knowledge base of traditional architecture of Kerala, made by Dr. A. Achyuthan and Dr. Balagopal T. S. Prabhu. The next paper is a syrvey of works relating to Kerala architecture written by S.A.S Sarma. The Third one is on iconography and sculpture, where Dr. Balagopal T. S. Prabhu highlights all the relevant points as reflected in *Śilparatna* and other authoritative texts. Dr. Jayan Erancheri Illam and Dr. K. N. N. Elayath write on *Tantrasamuccaya* and a Maṇipravāla text, *Puṭayūr Bhāṣa,* respectively. In the next paper, Dr. Unithiri is making an attempt to esablish that *Tantrasamuccaya* is more or less a free adaptation of *Puṭayūr Bhāṣa*. Following this, we have articles on three prominent treatises, namely, *Manuṣyālayacandrikā, Śilparatna* and *Bṛhatsamhitā* prepared by Jyotsna G., Dr. Unithiri and Dr. P. Manoharan. Anandakrishnan Kunholathillath gives us a picture of town planning in ancient India in his essay. Dr. C. Rajendran points out the intimate relation between Vāstuvidyā and Ecology. He, in another paper, provides an exhaustive study of environmental awareness in ancient India. Dr. C. M. Nilakandhan writes on the ecological awareness in the Vedas. Environmental Activism that now we experience all over India is the subject matter of Dr. P. V. Ramankutty's article. Dr. P.V. Narayanan's "Arthaśāstra: Scientific and Technical Aspects" is the last paper of this volume.

Thus, this volume, I hope, will inspire Sanskrit scholars as well as Scientists to take up combined projects and to make substantial contributions to the studies on Scientific Heritage of India.

Dr. N. V. P. Unithiri,
Professor and Head of the Department of Sanskrit,
University of Calicut.

PART A
Professor K. N. Neelakantan Elayath

PROFESSOR K. N. NEELAKANTAN ELAYATH

Born at Vazhoor, Kerala, on 27th February 1944. K.N. Neelakantan Elayath studied in Sree Sankara College at Kalady and took his B.A. Degree in Sanskrit in 1964 securing first calss and rank. He did his post graduation in Vivekananda College at Madras, and the Dept. of Sanskrit, Madras University and secured M A degree in Sanskrit in 1966 with first class and second rank. During his post graduation he had the opportunity to study under eminent scholars like Dr. V. Raghavan, Dr. K. Kunjunni Raja, V. R. Kalyanasundara Sastrikal, Prof. Tirujnanasambantam and S.Subrahmanya Sastrikal. Later he joined for M Lit. and carried out research under Dr.V. Raghavan on *Anubhūtisvarūpācārya* but left it on his appointment in the Madras Government Collegiate Service. Till 1969 he worked as Assistant Professor of Sanskrit in Government Arts College at Kumbakonam,Tanjore District, and later left the job and joined the Department of Sanskrit, University of Kerala, for Ph.D. as a UGC Research Fellow. He carried out his research under the guidance of Dr. A.G. Krishna Warrier who by then had joined as Professor and Head of the Dept. of Sanskrit at the Himachal Pradesh University, Shimla. In 1975 he got PhD in Sanskrit for his thesis *The Ethics of Sankara*. From 1972, for more than a decade, he taught Sanskrit at Sree Krishna College, Guruvayoor, and in 1984 he joined the Dept. of Sanskrit, University of Calicut, as Reader in Sanskrit. From 1990 onwards he is Professor of Sanskrit at Calicut University.

As a teacher for nearly three decades he has not only taught generations of students but also has guided many students in their research leading to Ph.D. from 1978 onwards. He has produced 15 M.Phil-s and 8 Ph.D.-s besides himself carrying out considerable research. He has brouht out publications, both papers and books, in various disciplines like Literary Criticism, Language Studies, Technical Sciences like Architecture and Music and Darśanas like Mīmāmsā, Yoga and Vedānta, though Advaita Vedānta always remained his most favorite subject.

In addition to teaching and research, he has attended All India Oriental Conferences and participated in National and International seminars, Philosophical Congress, Colloquiums and Workshops either as delegate or as resource person in different parts of India. He coordinated 8 Refresher courses in Sanskrit with different thrust areas in the Academic Staff College of the University of Calicut.

From 1975 onwards he has been serving as Member of the Post Graduate Board of Studies in Sanskrit, Member of the Faculty of Languages, and Member of the Academic Council of the Calicut University. In addition to being a subject expert for Indian Council for Philosophical Research and an expert for UGC Minor Research project for sometime, he has also served as Member of several appointment committees for the selection of Professors in many South Indian Universities. Presently he is a Member of Syndicate, Sree Sankaracharya University of Sanskrit, Kalady.

In 1984 he won the award of the Kerala Sahitya Academy for Vedic studies for his work in Malalyalam *Advaitadharmam*.

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5. *Svaritam* (Collected Papers), Lipi Publishers, Calicut, 2001.
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9. *Avaidikadarśanasaṅgraha* of Gangadhara Vajapeya Yaji, Calicut, 2003.

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Published more than 100 Research Papers in English and Malayalam on Vedānta, Alaṅkāra, Language Studies, Management Studies, Indian Architecture, Scientific Literature, Indian Philosophy and Performing Arts in National & International Journals and books. A few among them:

1. Intention as Semantic Condition in Pāṇini, *Aspects of Paninian Semantics,* Sahitya Academy, New Delhi, 2002.
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2. Hermeneutics and Literary Theories, Seminar on Contemporary Literary Theories, S.S University of Sanskrit Kalady, 25.10.96.
3. Nila's Literary Tradition in Sanskrit, National Seminar on Nila, Govt. Sanskrit College, Pattambi, 11.02.1998.
4. HRD Management in the Bhagavadgita. National Seminar on Some Aspects of Management in Ancient India, Aligarh Muslim University, 22.3.1998.
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7. Structure and Origin of Matter: Nyaya-Vaiseṣika Dichotomy, National Seminar on Applied Sciences in Sanskrit Literature, Agra University, Agra, 21.2.1999.
8. Hermenutial Tradition in Vedanta Philosophy, Lecture, S S University of Sanskrit, Kalady, 12.3.1999.
9. Sanskrit Commentaries in Kerala, National Seminar on Sanskrit Writings after Independence, University of Poona, 30.11.1999.
10. Scientific Methodology, National Seminar on Scientific Heritage of India, Govt. Sanskrit College, Pattambi, 28.1.2000.
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18. Sanskrit Resources for Music Therapy, National Seminar on Music Therapy, Music Therapy Research Center, Calicut, 9-10-2002.
19. Brahman, World and Mokṣa in Sankara's Advaita, National Seminar on Vedangas & Advaita Vedanta, Kadavallur Anyonya Parishat, Sree Ramasvami Advaita Temple, Kadavallur, 22-11-2002.
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21. Folklore in Atharvaveda, UGC Sponsored National Seminar on Folklore in Sanskrit, Dept of Sanskrit, University of Calicut, 8, 9 January 2003.
22. Influence of Sanskrit on Malayalam, National Seminar on Influence of Sanskrit on Regional Languages, Dept. of Sanskrit Osmania University, Hyderabad, 24, 25, January 2003.

Ph. D. GUIDED & AWARDED

(Name of Scholar, Title of Thesis, Year of Award)

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PART B

Indian Scientific Traditions

SECTION I

Astronomy and Mathematics

Scientific Methodology in Ancient India

K. N. Neelakantan Elayath

In addition to the sizable output in religion, philosophy and literature Sanskrit has vast store of writings on scientific subjects like mathematics, astronomy, chemistry, medical science and architecture. Though ancient Indians have made astounding progress in some of these basic and applied sciences, the methodology and arguments employed by them are not properly studied or investigated. Hence the reconstruction of ancient scientific methodology becomes a task for those who want to work on Indian science. Many of these works written in Sanskrit envisage knowledge of scientific postulates and other general notions. And Indian scientists might have employed several methods of investigation, as in other parts of the globe. But the ignorance of these methods has affected the proper understanding and assessment of Indian scientific thought, even to the extent of doubting the originality of their scientific achievements.

Historical Perspective

Even from the period of *Ṛgveda* Indians were aware of the laws of Nature that governed phenomena and of the definite laws of causality. In spite of the tremendous advancements in mathematics, these laws were not stated in terms of mathematics. No mathematical theorizing to account for physical phenomena is available in the scientific literature of India. Mostly, physical phenomena was qualitatively defined and

not quantitatively. And many Sanskrit literatures pertaining to science are silent about the methods and many notions remain to be discovered from available commentaries.

Thus we have to put together the clues availabe in scientific and philosophical works and their commentaries and various other sources and reconstruct the methodologies employed by Indians in scientific investigations.

Indians from a very early period distinguished between religion, philosophy and science. If there had been any overlapping it was because of the holistic attitude developed by them. The concept of two types of knowledge systems as superior and inferior (parā vidyā and aparā vidyā) in the Upaniṣads and the later notion of rational philosophy (*ānvīkṣikī*) and religious studies (*trayī*) are indicative of this attitude. Both in science and philosophy the basic methodologies are the same. All the postulates of science are accepted in philosophy also. The difference is that philosophy goes further into regions where science usually does not enter. And this is true even in the case of ancient Indian science.

Indian Context

Scientific method is the collective name for the process of investigation. Though its main features are observation and experimentation, it consists of several steps. They are formation of a hypothesis, defining concepts, making deductions from the hypothesis, collection and analysis of data, verification by experiments and finally integration of the result to the existing body of knowledge. Systematic doubt, verification and universality are the main features of this method. The scientific postulates include, also fundamental laws of thought and logic, like the principle of identity and the principle of contradiction. And it proceeds from certain basic assumptions like principle of casuality, principle of objectivity, principle of empiricism and principle of parsimony. The ancient Indian scientists accepted all these postulates and they followed all the procedures. But the details are not properly known. Dr. K.V Sarma ascribes this to a particular trend in Indian

tradition of "not keeping the record of the intermediary steps and arguments once the result is obtained". New formulations of theories, and frequent corrections and amendments made by subsequent writers especially in astronomy and mathematics may be a pointer to their deviation in methodology. In spite of the absence of details in many scientific treatises, we find considerable progress in the employment of scientific method in the early systems of Indian philosophy, especially in realistic and naturalistic philosphies like Nyāya, Vaiśeṣika and Sāṅkhya systems. These systems comprehended scientific method in the larger spectrum of pramāṇaśāstra, the science of valid means of cognition. All problems related to this were discussed under this head. They formulated several theories on the structure, origin and evolution of matter in their cosmological speculations. To attribute certain phenomena to "unseen power" (adṛṣṭa) may be due to the ignorance of proper methodology or absence of proper instruments. Pratibhā (intuition) and imagination also might have played an important role in their scientific investigations. But its excessive application was often checked by pramāṇaśāstra. We find an elaborated discussion on pramāṇas in most of the philosophical treatises of ancient India. These pramāṇas are accepted in all the scientific disciplines and some branches like Āyurveda has contributed substantially to the theory of pramāṇas.

Divinity of Scientific Knowledge

The traditional belief is that most of these sciences like religion are of divine origin. And even some of the scientific treatises in Sanskrit seem to endorse this view (brahmaṇā upadiṣṭaḥ). In fact, science in ancient India, as in any other parts of the world, is the result of observation and experiment. It is interesting to note that Nīlakaṇṭha Somayājī, a prominent medieval astronomer of Kerala, in his *Jyotirmīmāmsā*, clarified the exact nature of the so called divine instruction. He points out that 'divine-instruction' does not mean direct instruction by Gods but only chastening of the intellect through divine grace as a result of which authors could express their thought logically:

"granthakaraṇe devatāprasādaḥ mativaimalyahetuḥ tasya kutaḥ parīkṣaṇam? brahmaṇaḥ sarvajñatvāt .... avitathatvaniścayāt iti cet, manda, maivam, devatāprasādo mativaipulyahetureva. na ca brahmā ādityo vā svayamevāgatya upadiśet, tasmāt brahmaṇopadiṣṭamityetat āryabhaṭīyavākye naiva viruddham" (p.2)

[In the composition of the work, the blessing of God is the cause of clarity of the intellect (if some body raises the objection). Because Brahmā is omniscient and his words infallible, why should you examine them? Fool! it is not the case. The Divine grace is only the cause of sharpening of the intellect. Not that Brahmā or the Sun God will come down and give instructions. So there is no contradiction in the statement of *Āryabhaṭiya* that this knowledge is the divine instruction of Brahmā].

He also points out a passage from *Taittarīya Āraṇyaka* (1.2.1) which says that the means of determining the planetary positions are smṛti, pratyakṣa, aitihya and anumāna (recollection, perception, tradition and inference respectively:

smṛtipratyakṣamaitihyam anumānam catuṣṭayam /
etairādityamaṇḍalam sarvaireva vidhāsyate //

Interestingly a commentator glosses pratyakṣa in the above verse as sākṣipratyakṣa or *yogipratyakṣa*. One may thus conclude that as in the case of European science, Indian science was also the result of observation and experiment and not a product of speculation, intuition or introspection.

B. N. Zeal in his *Positive Sciences of the Ancient Hindus* has shown that in the investigation of any topic, Indian scientific methodology accepted the following procedures.

1. Proposition of the subject matter (uddeśya)
2. Ascertainment of the essential character by pramāṇas resulting in definitions (lakṣaṇa)
3. Examination and verification (parikṣā and nirṇaya)

The truth established through these procedure was called siddhānta, conclusion. However all pramāṇas are subsidiary to siddhānta and all

the scientific methods are auxiliary to pramāṇaśāstra.

The Test of Truth

The ultimate criterion of truth is considered to be samvādipravṛttijanaka that which culminates in fruitful activity. It is not coherence but correspondence with external objects. This is included in the discussin on pramāṇaśāstra, which deals with sources of human knowledge and its verification. The problems of pramāṇas are one of the major issues discussed in detail in most of the systems of Indian philosophy.

Observation

Indians include observation as a scientific method in pratyakṣa or perception. The nature of perception and its limits were carefully studied. The infra sensible (*atīndriya),* the observed, abhibhūta like the star in the mid day light, the unmanifest or potential (anudbhūta) are clearly distinguished. In pratyakṣa the Naiyāyikas insisted on the completion of the circuit of the consciousness and the minimum visible- the *trasareṇu-* was identified. The conditions of non-perception were clearly defined and their listing by Sāṅkhya philosophers is quoted in *Carakasamhitā.*

Atidūrāt sāmīpyād indriyaghātān mano' navasthānāt /
Saukṣmyād vā vyavadhānād abhibhavāt samānābhihārācca //

(Non-perception may be) due to extreme distance, extreme proximity, defective organs, non-steadiness of the mind, subtlety, veiling, suppression and blending with what is similar)

The word 'ca' (and) here refers to similar causes like the non-manifestation of effect in the cause.

Indians have also studied the fallacies or defects of observation resulting in illusion (bhrama) or superimposition (*āropa / adhyāsa).* Errors of observation was one of the important topics discussed in philosophical treatises under the head 'theory of illusion' (khyātivāda). According to Naiyāyikas perceptive knowledge becomes erroneous due to the defect of the sense-organ (as in the case of eye in jaundice)

defect of stimulus (sahakāri) like the absence of proper light, undue distance etc. in vision; rousing of the memory of similar objects (*samprayoga)* and the influence of mental dispositions like habit, prejudice etc. The detailed discussions on perception and its fallacies in different darśanas bring out the importance attached by Indians to scientific observation. In specific sciences, the phenomena were clearly observed and analyzed. Since the ancient Indians did not possess sophisticated instruments most of the scientific theories must have been formulated by the power of observation. Observation was the basis of many physical, chemical and astronomical theories. This also led to the method of classification, one of the important scientific processes. The definition and classification of categories, substances and qualities in Nyāya-Vaiśeṣika system are based on observation. In Āyurveda several theories are the result of precise and minute observation. In meteorology, weather fore-casts were made by the observation of the clouds and other atmospheric phenomena.

In scientific-planetary-astronomy (*jyotiśśāstra)* Indians have reached a remarkable degree of progress. For the determination of lunar constants determining the lunar periods and eclipses they went a step further. They scanned the heaven for long periods and revised astronomical parameters. It is recorded that Parameśvara, the Kerala astronomer, made observations of eclipses and configuration of planets for 55 years before formulating dṛggaṇita. Theories of planetary motion, computation of eclipses, theory of the rotation of the earth etc., were the result of observation of physical phenomena. The classification of insects in Zoology and classification of plants in Botany though based on external characters, are the result of repeated observations.

Inference

As in philosophy, in all branches of science, inference or anumāna was employed as a foolproof method of investigation. However, the Naiyāyikas and the Buddhists worked out its theoretical details. This is a process of ascertaining the truth through the medium of mark (liṅga) that a thing possesses. It is therefore based on the establishment of

invariable concomitance (vyāpti) between the mark and the object inferred. It is a rigorous formal statement in the form of five propositions-proposition to be established (pratijñā), the reason (hetu) ascription of the mark, the general proposition stating the vyāpti with an example (udāharaṇa), ascertainment of the existence of the mark (upanaya), and finally the conclusion (nigamana). The Buddhists accept causality and identity (tadutpatti and tādātmya) as the ground of inference. Vyāpti or invarible concomitance is established by agreement in presence (anvaya) and agreement in absence (vyatireka). According to later Naiyāyikas it is invariable and unconditional concomitance between two phenomina . Even a suspected condition (śaṅkitopādhi) should be absent and this can be removed by repeated observation (bhūyodarśana).

In addition to inference a hypothesis (kalpanā) properly tested and verified was considered as a method to ascertain a certain phenomena. Jayantabhaṭṭa in his *Nyāyamañjarī* says that a proper hypothesis should fulfill the following conditions:

1. It should not be in conflict with other observed facts or established thesis (dṛṣṭasiddhaye na dṛṣṭavighātāya adṛṣṭam kalpyate)
2. No unobserved agencies should be assumed when it is possible to explain the fact by observed agencies (dṛṣṭakalpanā)
3. When there are rival hypothesis the simpler should be preferred (lāghava)
4. When there are different hypotheses the immediate and relevant should be adopted rather than the remote (prathamopasthita)
5. Hypothesis should be verified by showing that it is deducted from a general proposition already established. (See B.N. seal)

Like perception this method of logic also was comprehended under the wider conception of pramāṇaśāstra. In fact, inference is one of the major methodologies of all sciences.

In mathematics, astronomy and medical science this

inferential method was applied and we have general logic and logic of special sciences. A typical example is the application of logic in Indian system of medicine. Logic, as found in Caraka's system is applied to the problems in the study of diseases, their causes, symptoms and remedies *(Vimānasthāna* Ch. IV).

Caraka at the very outset says that things are either existent or non-existent and they can be investigated by four pramāṇas - utterance of a reliable person (āptopadeśa), perception (pratyakṣa), inference (anumāna), and continuous argument (yukti) (1.11.17). A detailed discussion on pramāṇas is taken up in the relevant context of the *Carakasamhitā*. He classifies anumāna into three types: from effect to cause, from cause to effect, and from association other than causal relations. Yukti is sometimes differentiated from anumāna. When a conclusion is reached as a result of the examination of various causes and considerations, we have yukti. The example Caraka gives is the forecasting of good and bad harvest from the conditions of the ground, rains, climatic condition etc. It is also called ūha, a kind of guess work, by some commentators. According to others it is only an inference of the effect from the cause.

Logic in Āyurveda had twofold function. It was used not only for diagnosing diseases but also for debating purposes. On the occasion of the treatments of illness of rich people, physicians had to show their skill in debates and establish their thesis. The art of carrying on a debate successfully was considered to be an essential qualification of a good physician. In *Carakasamhitā* we have an elaborate treatment of debating techniques and a whole chapter is set apart for its discussion *(rogabhiṣagjitīyavimāna,* III.8).

Caraka even goes to the extent of saying that hetu is the foundation of all knowledge - hetur nāma upalabdhikāraṇam. And his four-fold classification of siddānta brings out the importance of discussion and debate in arriving at the truth (sarvasiddhānta, pratitantrasiddhānta, adhikaraṇasiddhānta and abhyupagama siddhānta).

In arithmetic and geometry Indian theories were very close to modern European science. Indians have worked out all achievements in these two disciplines by continuous hard work in the realm of abstract thought.

Experiments

Experiments have been always the major methodology in scientific investigations. For experimentations the ancient Indian scientists must have used some instruments, though the details of them are not fully known. It is possible that the astronomers in India used certain instruments for observation and experiments. In some context these instruments are casually mentioned but not described in detail. The *golapāda* of *Āryabhaṭīya* mentions an automatically rotating golayantra (sphere) keeping pace with time for astronomical demonstrations.

In Āyurveda experiments were conducted on the dead bodies. The reference to several sharp instruments in surgery reveals that there were experiments. Again the description of about five hundred herbs and their therapeutic uses would not have been possible without experiments. The knowledge of toxicology dealing with the nature and effects of poisons point to experimentations. Several toxic plants were identified and studied by them. In the kitchens of great rulers, experts in poisonous substances were employed to examine the food prepared for the king. This would not have been possible without experiments.

In chemistry the preparation of medicines, preparation of colours and cosmetics presuppose the employment of experimental method. The knowledge of about eighteen mercury compounds and various chemical processes like extraction, purification, liquefying, melting, tempering etc. were the result of continuous trial and error method.

In the field of ancient architecture (vāstuvidyā) which reached a high degree of perfection in India, all the achievements were the results

of centuries of experiments and theorization. Its concept of vāstumaṇḍala from which design theories are derived to suit different types of buildings, its system of measurement yavamāna and puruṣamāna, the yoni concept (system of defining the orientation of vastu with respect to different directions) all point to experimentation. In the selection of a site suitable for the construction of a building a systematic method through experiment and observation is prescribed. The ideal site should satisfy the following conditions: even topology, fertile soil for useful plants, compact soil conditions for supporting the building, and availability of water and moderate climate. When most of these conditions are known through observation, compact soil condition is tested with experiments. To cite an example, a spot is first excavated and it is filled with excavated soil. If it is completely used for filling, then the ground is not compact and it is not suitable for building. If a good portion of the excavated soil remains even after filling, it shows the compact nature of the soil and so it is suitable for houses. The details of this process are furnished in *Manuṣyālayacandrikā* and *Bṛhatsamhitā.*

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Development of Mathematics in India- Myths and facts

C. P. Narayanan

Mathematics is of basic importance in the development of knowledge as a whole, especially of science. The reason is that it deals with the most abstract and most general aspects of objects and phenomena while other branches of knowlege deal with their concrete and particular aspects. This is demonstrated by the bulk of discoveries made by our ancestors in mathematics and other branches of knowledge during the past thousands of years.

But a clear picture of the contribution made by India in the past is not available since long periods of Indian history are still shrouded in darkness due to non-availability of material or our inability to decipher inscriptions available from Harappa and Mohanjodaro. In spite of this it is recognised by historians of science that India had made invaluable contributions to mathematics during the last 5000 years.

The Europeans who came to India during the last 500 years made numerous attempts to belittle and distort contributions made by India to various branches of knowledge, especially science. The same was the manner in which they treated other third world countries. Perhaps this was part of their strategy to establish their intellectual superiority over peoples in the colonies. If one cannot rise above others intellectually, then characterise them as pigmies that they look relatively smaller, such a characterisation of Indian knowledge

was making rounds in 18th and 19th centuries because of the arrogance of the imperialists and due to their ignorance of the contributions made by our ancestors. Only by 20th century they started a review of their position on the basis of studies made by various scholars. Discovery of Harappa-Mohanjodaro civilization and the empire of Asoka through archeological studies compelled scholars all over the world to recognise that India had a long and rich history and that it had made invaluable contributions to various branches of knowledge.

After independence serious efforts were made by scholars in India to study our past systematically and to find out data regarding the dark ages of India's history through re-reading and deep study of available material and through archeological studies. Such studies have established that India had contributed much to the humanity's wealth of knowledge. Our contributions to medicine in the form of Āyurveda, to sciences especially mathematics, to philosophy through the Buddhist-Jaina contributions as also Upaniṣads and to art in various forms are now recognised all over the world.

The earliest Indian civilizations are considered to be those of Harappa, Lothal and Mohanjodaro. They had developed urban centres laid out with detailed planning. Since nobody has so far been successful in deciphering their scripts we do not know much about the wealth of knowledge they had inherited and created. But from the Vedic period we have records, however incomplete and scanty they may be. Thus we have *Śulbasūtras* and Vedāṅgas about 3500 years old developed by Baudhāyana, Āpastamba, Katyāyana and others and *Vedāṅgajyotiṣa* athored by Lagadha. The former shows that they knew about the problem of squaring a circle and had at least some idea of incommensurable numbers. *Vedāṅgajyotiṣa* shows how far astronomical studies had developed in India till that time. After the Vedic period mathematics and other branches of knowledge thrived during the Buddha and Jaina periods up to 200 BC. Afterwards the tradition was kept up during the Kushana and Pandya dynasties. But the golden period of Indian mathematics was 400-1200AD when rich contributions of Āryabhaṭa, Varāhamihira, Bhāskara I, Brahmagupta,

Śrīdhara, Bhāskara II and others diversified , expanded and enriched Indian mathematics and spread its fame far and near. Afterwards one sees a decline in Indian mathematics, but in Kerala a School led by Mādhava, Parameśvara and Nīlakaṇṭha made major contributions to make it a forerunner of modern mathematics later developed in the West.

Whether it be *Śulbasūtras, Vedāṅgajyotiṣa, Āryabhaṭīya, Pañcasiddhāntikā, Mahābhāskarīya* or other major contributions made by various other mathematicians and astronomers, they are milestones in the development of mathematics and astronomy not only in India but the world as a whole. Many mathematicians in India were ahead of the times. This is indicated by their contribution of zero and the number system based on the ten digits. Āryabhaṭa's theory of earth's rotation on its axis was much ahead of others and the development of Gregory's and Leibnitz's infinite series for the inverse tangent and π, 200 years before they were developed in the West. Indian mathematicians were able to develop mathematics cogently and rigorously as is evidenced by contributions of Āryabhaṭa, Bhāskara, Mādhava and Nīlakaṇṭha, to mention a few of the outstanding Indian mathematicians.

Instead of highlighting these contributions and their importance and exhorting the present generation to emulate them, the authorities in recent years have started the practice of eulogising unscientfic and untenable pieces of knowledge developed in the past and prescribing them as subjects of study in educational institutions. One such area is astrology. Astronomy and astrology though appear to be a twin branch of science, astronomy is defined as the scientific study of "celestial bodies" by the *Concise Oxford Dictionary,* while astrology is assumed "the study of movements and relative positions of celestial bodies interpreted as an influence on human affairs". While the former is recognised as true by all educated people, the latter is not acceptable to many. Nor are the interpretations and predictions by astrologers found to be universally true. Nor is it true to say that astrology had its origin in India. No mention of astrology is found in *Vedāṅgajyotiṣa* by

Lagadha which is the oldest available (a few centiures before Christ) text on the subject in India. Even well known astronomers like Āryabhaṭa do not make any mention of astrology while there is detailed treatment of the subject by Varāhamihira and later authors.

But material on astrology is available from Chaldea and Babylon, which form parts of the present Iraq, centiures before Christ and hence it is generally accepted that this branch of knowledge had its origin in these countries rather than in India.

Though the calculations regarding motion of celestial bodies done by astrologers are generally found to be correct, their assumption that these bodies, particularly the Sun and planets influence the lives of human beings is not found to be logical, empirically true and hence scientific. Hence teaching astrology in our educational institutions to form part of our treasure of knowledge is neither prudent nor productive. It helps only to keep people superstitious, ignorant and lethargic. It will not help them to become enlightened. It will have the same effect on humanity as did Ptolemy's theory of universe have on them during the middle ages.

Another similar venture is the introduction of "Vedic Mathmatics" into the curriculum in recent years .The inspiration for this is a book with this title written by a former Śaṅkarācārya of Puri, Bharatikrishna Tirtha Maharaj, who is supposed to have written the book in 1960 based on 16 sūtras found in a pariśiṣṭa of *Atharvaveda* available to him only. His scientfic sense is evident from his own words: Vedas should contain within themselves all the knowledge needed by mankind realising not only to the so called spritual matters but also to those usually described as purerly secular temporal world. This shows that Swamiji and his cohorts cosidered treasure of knowledge as closed one which should be created for once and for all at some point of time and deposited in *Vedas* or similar texts. This is an approach to knowledge which completely denies chance of acquiring it through life experiences or embellishing it in the same manner. This is contradictory to the experience of humanity which has been expanding

its wealth of knowledge over time on the basis of its continuous interaction with nature.

What Thirthaji Maharaj deals in the book is mere arithmetic or various methods of simple calculations. It does not deal with ideas in various branches of mathematics developed during the last 500 years at all. But Swamiji and his admirers claimed that all of them could be developed from Vedic or upavedic sūtras as he had done in his book even though till this day nobody has been able to trace the so-called sūtras of Thirthji to any known Vedic text. Nor has anybody attempted to develop modern ideas in mathematics from Vedic sources.

This is mythification or mystification of knowledge, particularly science, pure and simple. This is a method known to India in the previous millenniums when the powers-that- be of the day inflicted their ignorance or superstition over others in order to establish or maintain their hegemony over others.This happened in the Vedic period, during the later years of Buddhism and Jainism and above all when Brahminism established its sway overpowering all other traditions.

The present eulogisation of illogical or lesser developed knowledge of yester years like jyotiṣa or Vedic mathematics is only a repetition of this earlier trend to channelise and utilise knowledge to establish and retain hegemony over the society. This may be beneficial for a few in power to enjoy themselves. But this is harmful to the vast majority of people whose well-being demands continuous and logical expansion of knowledge and its application to ensure that their wants are fulfilled, their life protected and social evils eliminated. The mythification or mystification of science will have only the opposite effect, which is to be prevented at all costs.



Astronomy and Mathematics in Medieval Kerala with Special Reference to Nila Valley

N.V.P.Unithiri

As reported by Prof.K.V.Sarma,an old palm-leaf document records a line of tradition of astronomy and mathematics in Kerala, which extends from 13th to the 17th centuries. Govinda Bhaṭṭatiri of Talakkulam (1237-95) - pupil: grandfather of Parameśvara (13th -14th century)- grandson-pupil: Parameśvara (c.1360-1455)-Dāmodara (15th c.) - pupil: Nīlakaṇṭha Somayājī (1444-1545) - pupil: Jyeṣṭhadeva (c.1500-1600) - pupil: Acyuta Piṣāroṭi (1550-1621).

There are some other lines of tradition also which are recorded.

Basic Features of Kerala Astronomy

1. Solidarity with the Āryabhaṭan system

At least from the 7th century, Kerala had been the stronghold of the Āryabhaṭan school of astronomy. All the later Kerala schools are based on the Āryabhaṭan system. Most of the available commentaries on the *Āryabhaṭīya* have been written by Kerala scholars (Parameśvara, Nīlakaṇṭha Somayājī, Kṛṣṇa, Ghaṭīgopa). Kerala mathematicians have generally made the revision, supplementation and correction of Āryabhaṭan astronomy and mathematics in order to get more accurate results.

2. Kaṭapayādi system

An easy method of expressing numbers through letters, known as

the Kaṭapayādi system, was extensively used in Kerala down the centuries. The legendary figure Vararuci is credited with this innovation. The authorship of *Candravākyas* (Moon computation sentences), composed in this notation- गीर्णः श्रेयः etc. is also ascribed to him. The effectiveness of the notation rests in the fact that even long and complicated numbers can be expressed through seemingly meaningful expressions and verse-bits, so that they can be easily verified and remembered. This system may be explained as follows:

(a)

1	2	3	4	5	6	7	8	9	0
ka	kha	ga	gha	ṅa	ca	cha	ja	jha	ña
ṭa	ṭha	ḍa	ḍha	ṇa	ta	tha	da	dha	na
pa	pha	ba	bha	ma					
ya	ra	la	va	śa	ṣa	sa	ha	ḷa	

(b) In conjunct letters only the value of the final consonants is to be taken into account.

(c) Vowels following the consonants have no value.

(d) ña and na and pure vowels stand for zero.

(e) Numbers should be computed in the reverse.

eg: ācāryavāgabhedyā
1 4 3 4 1 6 0

The simple rule for this notation is given by the verse:

नञावचश्च शून्यानि, सङ्ख्याः कटपयादयः।
मिश्रे तूपान्त्यहल्सङ्ख्या, न च चिन्त्यो हलस्वरः ।।

(*Sadratnamālā* of Śaṅkara Varmā)

There is another type of notation also which is prevalent generally in India. It had also been used in Kerala.That is भूतसङ्ख्या.

Synonyms of sky (खम्, आकाशः etc) -1, eye (अक्षि, नयनं) - hand (भुजः etc) - 2, गुण - 3, वेद, समुद्र - 4, भूतम्, इन्द्रियम् - 5, रस - 6, ऋषि - 7, नाग, गज - 8, नन्द - 9, दिक् - 10, रुद्र - 11, सूर्य - 12 etc.

eg: नन्दनयनाब्धि - 429

Parahita and Dṛg system

Haridatta (c.650-700) promulgated the Parahita system in A.D.683 on the basis of Āryabhaṭan astronomy. He propagated this system through his two works *Mahāmārganibandhana* and *Grahacāranibandhana*. The system postulates a correction called bhaṭābdasaṁskāra *or* śakābdasaṁskāra to the Āryabhaṭan system and presents all the data, directions and sine-tables necessary for the computation of the planets and for all allied matters. Śaṅkara Varmā of Kaṭattanāḍu in his *Sadratnamālā* records this event as follows:

आचार्यार्यभटप्रणीतगणितं प्रायः स्फुटं तत् खलु
गोत्रोत्तुङ्गमिताब्दके व्यभिचरन् ब्रह्मादिसिद्धान्तके।
दृग्वैषम्यवशाद् महास्थलमिते कल्यब्दके निश्चितः
संस्कारो विबुधैर्यतः परहितत्वं तेषु वीनेष्वयम्।। (6.1. 3)

गोत्रोत्तुङ्ग - 3623
महास्थल - 3785

This verse means : the astronomical treatise composed in Kali 3623 (A.D.522) by Āryabhaṭa gave well-nigh accurate results, whereas the siddhāntas ascribed to Brahmā etc. had (by that time) tended to be inaccurate. (When its results too tended to be inaccurate as exemplified by them) not tallying with observation, the correction called parahita was adopted by the wise in Kali 3785 (A.D.683) for the planets other than the Sun.

Parameśvara promulgated the widely popular Dṛk system in AD 1431. It is also based on the *Āryabhaṭīya* and modelled on Haridatta's work.

Dṛkkaraṇa, ascribed to Jyeṣṭhadeva of the 16th century, records the promulgation of these systems in the following (Malayālam) verses:

paṇḍuḷḷa gaṇitajñanmār connatoṭṭu parañjiṭām
kalyabdam trisahasrattil param cennuḷḷa nāḷilu

ottuvannīṭumārilla grahaṇādikaḷonnumē
karaṇaṅṅaḷumottīṭā siddhāntaṅṅaḷumottiṭā
tadā hyāryabhaṭo nāma gaṇakastvabhavad bhuvi
jñānatuṅgēti kalyabde jātanāyavanītale
girituṅgeti kalyabde gaṇitam nirmitam param
sāstram āryabhaṭīyākhyam tasmin paryayam uktavān
ivayannēkkupāyēna kuṟacciṭṭum karēttiyum
kalyādidhruvami illāte oppiccān annu paryayam

Meaning: Now shall I set out in brief what early astronomers enunciated. Before Kali 3000, the eclipses and other observed results did not tally with the astronomical manuals or the siddhāntas.Then, in Kali year 'jñānatuṅga' (3600 = A.D.499) an astronomer by name Āryabhaṭa was born in this world. In the Kali year girituṅga (3623 = A.D 522) was his work *Āryabhaṭīya* composed and there he stated the revolutions of the planets. He had adjusted these revolutions by reduction and addition in such a way that there was no zero correction at the beginning of Kali.

pinneyiggaṇitattinnu nīkkam kaṇḍitu bhutale
mandasthaleti kalyabde tanuteti śakābdake
palarum gaṇitajñanmār kūṭe nokkīṭṭu veccatu
kalyabdād girituṅgonād śeṣam veccu perukkaṇam

* * *

pērum parahitam ennu gaṇitam sūkṣmamennitu
iti niśacitya palarum ācariccavanītale.

Meaning: In course of time , deviations were observed in the results arrived at by this computation. Then in the Kali year 'mandasthala' (3785=AD 684) equivalent to तनुता (606), several astronomers gathered together and derived by observation a system, wherein the correct number of revolutions were to be found by multiplying the current Kali year minus 'girituṅga' (Kali 3623 viz. Āryabhaṭan epoch) by the yearly bhaṭābda or śakābda corrections ennunciated.This system was termed parahita and many followed it being assured of its accuracy.

cirakālam kazhiññappol nikkam vaḷare vannitu
raṅgaśobhā nu kalyabde kaścid vipravarastadā
paścimāmbhodhitīrattu ninnu nokkīṭṭu veccatu.

Meaning: When a long time had elapsed, there occurred substantial deviation.Then a noble Brahmin, residing by the western ocean revised it, the parahita system, by means of astronomical observations in the Kali year रङ्गशोभा नु (4532- AD. 1431). This denotes the dṛk system enunciated by Parameśvara of Vaṭaśśeri.

Prominent Kerala Astronomers

Mādhava of Saṅgamagrāma (c. 1340-1425)

Mādhava is well known as Golavid (Master of spherics). Saṅgamagrāma may be Irriññālakuḍa. Ilaññippalli Illam?

In his *Veṇvāroha* he evolved a facile procedure to read out the true positions of the moon every 36 minutes. Among his known works are *Lagnaprakaraṇa* and a table of moon-mnemonics correct to seconds. His *Mahājyānayanaprakāra* and *Madhyamānayana prakāra* contain novel theorems and computational methods evolved by him. It seems that Mādhava had composed a comprehensive treatise on astronomy and mathematics, which is yet to be discovered. It may be supposed to contain the numerous single and group of verses enunciating computational procedures, theorems and formulae. They are quoted as Mādhava's by later writers like Nīlakaṇṭha Somayājī. Possibly Mādhava wrote a work of Gola also.

Parameśvara of Vataśśeri (c. 1360-1455)

Parameśvara, one of the greatest astronomers of Kerala revised the parahita system through *Dṛggaṇita* in 1431. He belonged to Ālattiyūr grāma near Tirūr in South Malabar. His house Vataśśeri is situated on the confluence of river Nīḷa with the Arabian sea. He carried investigations on the sandy banks of the river. He also observed a lot of eclipses. He recorded them in detail in his *Siddhāntadīpikā*. He was a disciple of Saṅgamagrāma Mādhava.

Parameśvara authored about 30 works including original treatises and commentaries, both on astronomy and astrology. Original writings on astronomy- *Dṛggaṇita,Goladīpikā (3volumes), Grahaṇāṣṭaka, Grahaṇamaṇḍana, Grahaṇanyāyadīpikā, Candracchāyāgaṇita, Vākyakaraṇa etc.* Commentaries - *on Āryabhaṭīya, Mahābhāskarīya, Laghubhāskarīya, Sūryasiddhānta, Laghumānasa, Līlāvatī etc.* Some of his commentaries like those on *Āryabhaṭīya* and *Mahābhāskarīyabhāṣya* are very much valuable for the historian of Indian astronomy because they contain the enunciation of some of his new findings, theories and interpretations.

Nīlakaṇṭha Somayājī (1444-1545)

Nīlakaṇṭha Somayājī of Tṛkkaṇṭiyūr near Tirūr in South Malabar was as prominent as his grant teacher Parameśvara. According to his own description in some of his works, he was a Namboodiri of Keḷallūr family. He was patronised by Āzhvāñcheri Tamprākkal (Netranārāyaṇa).

His *Tantrasaṅgraha* is a comprehensive treatise on astronomy. *Grahaṇanirṇaya, Candracchāyāgaṇita, Goḷasāra, Siddhāntadarpaṇa, Āryabhaṭīyabhāṣya, Jyotirmīmāṃsā, Grahaparīkṣākrama* etc. are his other works.

Acyuta Piṣāroṭi (c.1550-1621)

Acyuta Piṣāroṭi of Tṛkkaṇṭiyūr was the teacher of Melputtūr Nārāyaṇa Bhaṭṭatiri. *Sphuṭanirṇaya, Rāśigoḷasphuṭānīti, Uparāgakriyākrama, Uparāgavimśati,* commentaries on *Veṇvāroha* and *Sūryasiddhānta* etc. are his important works.

The tradition of maintaining accuracy in astronomy was strong in Kerala. For exampale, Parameśvara in his *Dṛggaṇita* says:

दृश्यन्ते विहगा दृष्टा भिन्नाः परहितोदिताः।
प्रत्यक्षसिद्धाः स्पष्टाः स्युर्ग्रहाः शास्त्रेष्वितीरितम्।।
सत्कर्मोदितकालस्य ग्रहा हि ज्ञानसाधनम्।

अस्पष्टविहगैः सिद्धः कालः शुद्धो न कर्मणि।।
ये तु शास्त्रविदस्तद्वद् गोलयुक्तिविदश्च तैः।
स्फुटखेचरविज्ञाने यत्नः कार्यो द्विजैरतः।।
सञ्चिन्त्येति समालोच्य पूर्वतन्त्राणि यत्नतः।
स्फुटयुक्तिं खेचराणां गोलदृष्ट्या समीक्ष्य च।।
स्फुटखेचरविज्ञानं शिष्यैर्यैः प्रार्थितं द्विजैः।
तेभ्यो दृग्गणितं नाम गणितं क्रियते मया।। (1.2-6)

Meaning: Planets computed by the parahita system of astronomy are found to be away from their observed positions. In the science of astronomy, however, it is stressed that the observed positions are the true positions. Planetary positions alone are the means of ascertaining the times for auspicious rites. And, times indicated by incorrect planetary positions are impure for rites. Hence by those twiceborns who know astronomy and are scholars in spherics, effort should be made towards understanding planetary positions which are true to observation. After thinking thus and after examining previous texts studiously, and through the spherical view finding out the accurate position of sphere, the science known as dr̥ggaṇita consisting of the accurate knowledge of spheres is created by me.

It is notable that Parameśvara tried his best to perfect his system by astronomical observations for a number of years. He himself recorded this:

ग्रहेन्द्राः पञ्चपञ्चाशद्वर्षकालं निरीक्षिताः।
दृशा मया, तदा भिन्ना दृष्टाः परहितोदिताः।।

(Quoted by Nīlakaṇṭha Somayājī in his *Āryabhaṭīyabhāṣya*). This means: the planets had been scanned by me for fifty five years. Their positions computed according to the parahita system were all different from those observed.

Nīlakaṇṭha Somayājī also states on this: परमेश्वरस्तु

रुद्रपरमेश्वरात्मजनारायणमाधवादिभ्यो गणितगोलयुक्तीरपि बाल्य एव सम्यग् गृहीत्वा तेभ्य एव क्रियमाणप्रयोगस्य दृग्विसंवादं तत्कारणं चावधार्य शास्त्राण्यपि बहून्यालोच्य पच्चपञ्चाशद्वर्षकालं निरीक्ष्य ग्रहणग्रहयोगादिषु परीक्ष्य समदृग्गणितं करणं चकार।
(*Āryabhaṭīyabhāṣya,*TSS,1957, p.54)

Meaning: Parameśvara, too imbibed well, in his younger days the rationale of mathematical and spherical astronomy from astronomers like Rudra, Nārāyaṇa, son of Parameśvara and Mādhava of Saṅgamagrāma. He identified the differences between observed planetary positions and those derived from the computational methods taught by earlier authorities and understood the cause of the differences. He thought over the enunciations found in several texts,verified them with the eclipses and planetary conjunctions, and, from a consideration of all matters, composed his *Dr̥ggaṇita.*

After several arguments and enumerations of eclipses Parameśvara says as follows:

उक्तेभ्योऽन्ये चोपरागा मया दृष्टा विवस्वतः।
इन्दोश्च बहवो दृष्टास्ते तु नोदाहृता इह।।
एतानतीतोपरागान् सञ्चिन्त्य परकल्पिताः।
विलिख्यन्ते मया भानु-चन्द्र-चन्द्रोच्चराहवः।।

(pp.86-87)

Meaning: Many more solar eclipses as also lunar eclipses than those enumerated also have been noticed by me, but they are not set forth here. And, I am indicating below the correct positions of the Sun, Moon, Higher Apsis and Node, as determined on the basis of these past eclipses.

Reference may be made in this connection to a unique work of Nīlakaṇṭha Somayājī entitled *Jyotirmīmāmsā*. It is solely devoted to discussions on astronomical theories, apparent inconsistencies between computed and observed results and enunciation of corrections. He stresses on the experimental nature of astronomical science.

Anticipation of Modern Discoveries

Mathematics and astronomy are exact sciences which involve fund of rational thinking. So it is quite natural that a few of the findings of modern mathematics are found anticipated, partly or fully in the works of ancient and medieval Indian astronomers. A few of these anticipations as recorded by K.V.Sarma, may be listed below:

1) Reduction to the ecliptic by Tycho Brahe (1546-1601). Enunciated by Acyuta Piṣāroṭi (1550-1621) in his *Sphuṭanirṇaya:* simplified formulae in his later work *Uparāgakriyākrama:* and both the formula referred to in *Rāśigoḷasphuṭānīti.*

2) Irrationality of *π* by Lambert (1671). Categorically stated by Nīlakaṇṭha Somayājī (1444-1545) in his commentary on *Āryabhaṭīya:* येन मानेन मीयमानो व्यासो निरवयवः स्यात् तेनैव मानेन मीयमानः परिधिः पुनः सावयव एव स्यात्..... निरवयवत्वं तु न लभ्यमिति भावः I (Gaṇita, 10). This means that ð is an irrational number.

3) Leibnitz's (1646-1716) Power series for ð Implied in the verse व्यासे वारिधिनिहते etc of Saṅgamagrāma Mādhava (1360-1425) quoted by Śaṅkara Vāriyar (1500-60) in his *Kriyākramakarī* on *Līlāvatī.*

4) Gregory (1638-75) and Leibnitz's series for the inverse tangent. Enunciated by Mādhava and quoted by Śaṅkara Vāriyar in *Kriyākramakarī.*

5) Newton's (1642-1727) Power series for the sine and cosine. Implied in the verse निहत्य चापवर्गेण, etc. by Mādhava, quoted in the anonymous commentary in verse on Nīlakaṇṭha's *Tantrasaṅgraha.*

6) Newton - Gauss Interpolation formula (upto the second order). Enunciated by Govinda Svāmī (c.800-850) in his com. on *Mahābhāskarīya.*

7) Taylor Series approximations for sine and cosine functions (upto the second order of small quantities). Taylor (1685-1730). Enunciated

by Saṅgamagrāma Mādhava and quoted by Nīlakaṇṭha in his *Āryabhaṭīyabhāṣya.*

8) Gregory's expansion of third order Taylor series approximation of the sine (A.D.1668). Equivalent formula for the first four terms, with a minor change, enunciated by Parameśvara (1360-1455) in his *Siddhāntadīpikā* on *Mahābhāskarīyabhāṣya.*

9) Lhuiler's formula for the circum-radius of a cyclic quadrilateral (A.D.1782). Enunciated by Parameśvara in his com. on *Līlāvatī.*

10) Mean value theorem of differential calculus. Parallel theorem promulgated by Parameśvara in his *Siddhāntadīpikā.*

The foregoing observations reveal without any doubt that to the seiences of astronomy and mathematics, the contribution of Kerala, especially those parts of Niḷā valley, are very much substantial.

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Āryabhaṭīya - A Mathematician's View

K.S. Subramanian Moosath

In this paper we make some observations on the Mathematics discussed in Āryabhaṭīya *based on the developments in Mathematics from ancient to modern. The contributions in the areas of algebra, calculus and geometry are under discussion. On the basis of the fundamental ideas explained in it and the methodology adopted, one may agree that this ancient classical work is surely in the top list for the study of scientific and philosophical achievements of humanity.*

Here we look at some aspects of the Mathematics discussed in the *Āryabhaṭīya* of Āryabhaṭa. Our observations on *Āryabhaṭīya* is based on the Critical Edition of *Āryabhaṭīya* by K.S. Shukla in collaboration with K.V. Sarma.

Most of the ancient works have a practical origin. The ancient Mathematics developed in various civilizations as a practical science has a systematic unique way of thinking, spread over the fields of number system, arithmetic, geometry and calculus. The fundamental ideas in these areas were developed (simultaneously in certain cases) in different ancient civilizations. From this foundation with more and more contribution from different cultures, Mathematics (from ancient to modern) has made very exciting and tremendous achievements.

Developements in algebra started from number system and

arithmetic, then moved to the practical problems involving linear equations. Then whole set of equations, quadratic and higher orders changed the face of algebra. More and more structures - group, ring, field etc.- came in. Geometric studies also has a way to these abstract ideas by studying symmetries and group of motions. Also algebraic tools are effectively used in the study of geometric problems and a new branch, algebraic geometry, has developed in the modern Mathematics. In *Ārybhaṭīya*, Āryabhaṭa has given a way of expressing numbers using Sanskrit alphabets and the notational places are also explained. Many computational methods like squaring, cubing, square root, cube root, product of factors from their sum and squares, quantities from their difference and product, interest on principal, simplification of the quotients of fractions, reduction of two fractions to a common denominator are given. Problems involving linear equations like unknown quantites from equal sums, unknown quantities from sum of all but one, method of solving residual and non-residual pulverisers are also given. The power of computation and making it into a theory given in *Ārybhaṭīya* is an excellent art of work. As an example we explain the method of finding cube root of a number.

Cube root of a Number

From the unit place of the given number mark the places as cube place(c), first non-cube place (c), second non-cube place (c), cube place, first non-cube place and so on. From the digit in the c place of the left end of the given number (if the left end digit is not in c place take the number having all the digits upto the c place) subtract the largest possible cube. Note separately the cube root of the number which is subtracted. To the right of the remainder write the next digit from the given number and divide it with three times the square of the number which was noted separately. Write the quotient in the right side of the number that noted separately. In the right side of the remainder write the next digit in the given number and then subtract thrice the product of the quotient and the cube root noted separately (the above said division should be done in such a way that this

subtraction is possible). In the right side of the remainder write the next digit in the given number. Subtract the cube of the quotient that we wrote separately.

Write the next digit to the right side of the remainder and divide it with thrice the square of the number written separaely. Write the next digit in the given number to the right of the remainder and repeat the process until the digits in the given number exhaust. The number obtained from the integers wrote separately is the cube root.

Example: 121287375

1 2 1 2 8 7 3 7 5

c" c' c c" c' c c" c' c

121

64

$3.4^2=48$ | 572 | 9

432

1408

$3.9^2.4=$ 972

4367

$9^3 =$ 729

$3.(49)^2=7203$ | 36383 | 5

36015

3687 $\sqrt{3}$

$3.5^2.49 =$ 3675

125

$5^3 =$ 125

0 495

So (121287375) = 495.

Present day Calculus deals with several variables and more techniques of differentiation and integration are involved. From finding length, area, volume to integration and then the differentiation, calculus grew with more and more sophisticated tools. On the other

hand the study of sequences, series, etc, lead to the concept of limit, function, etc.

In *Ārybhaṭīya* methods for finding area of triangle, circle, trapezium and of plane figures are given. Also it explains the way to find volume of right pyramid and sphere. On series, a number of problems - the sum (or partial sum) of a series in arithmetic progression, number of terms in an arithmetic progression, sum of the series 1+(1+2) + (1+2+3) + ... to n-terms, sum of the serieses $\sum n^2$ and $\sum n^3$ are also discussed.

Here one thing to mention is that the excellent simple geometrical proof of some of these results by Nīlakaṇṭha Somayājī reveals the authenticity of these results and the highly intellectual mind behind it with a good deal of total perception on these ideas. Another remarkable result given is the value of π. Āryabhaṭa has given a value for the π and he mentioned it as an approximate value. The follow up on π and the series expression developed for π by Mādhava. He has considerable Mathematical insight and a whole lot of modern ideas of calculus underlies in it.

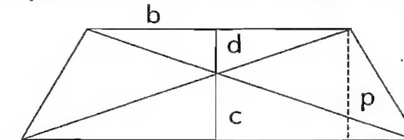
Here we give the method of finding the area of trapezium as explained in *Ārybhaṭīya*.

Area of a Trapezium and Length of Perpendiculars

Length of the perperndicular on the base from the point of intersection of diagonals $= \frac{\text{base x height}}{\text{(base + face)}}$

Length of the perperndicular on the face from the point of intersection of diagonals $= \frac{\text{face x height}}{\text{(base + face)}}$

Area of the trapezium = 1/2 (base + face) x height.



base - a, face - b, height - p, length of perpendiculars - c (from base), d (from face).

c = ap/(a+b), d= bp/(a+b), Area - 1/2(a+b)p

Geometry is one of the areas which made a considerable change in Mathematics. From the goemetry of plane figures to linear geometry and then Euclid's axiomatic system, geometry was leaping ahead. Till the 19th century Euclid's geometry enjoyed absolute majority. But the non - Euclidean geometry was a real break- through and the whole approach to geometric problems took a new turn. With more abstract concepts and many new tools Differential Geometry, the present day geometry, is a major subject in the modern Mathematics.

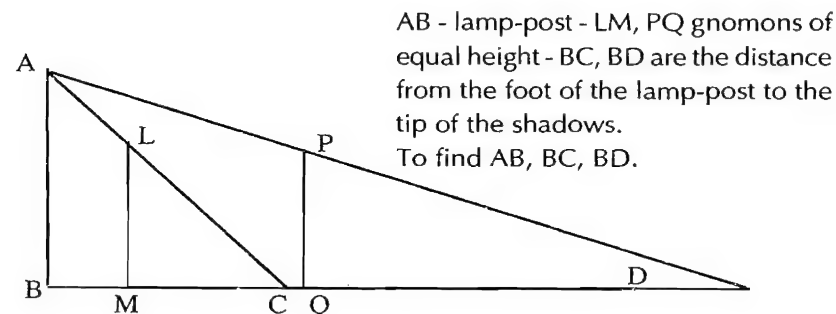
In *Ārybhaṭīya* the concept of square and cube are given and the constructrion of circle, triangle and quadrilateral are also explained. Geometric computation of Rsines, derivation of Rsine differences, the length of the shadow, height of the lamp-post given are the best examples of how geomtry of plane figures were intelligently used. Pythagorus theorem is another result given, which was known to Indians many years ago. The problems dealt here reveals the geometric insight of our ancient age. As an example we give the method explained for computing the height of the lamp-post and the distance between the tip of the gnomonic shadow and the foot of the lamp-post.

Height of the lamp-post and distance from the tip of the gnomon shadow and the foot of the lamp-post

Here two gnomons of equal height in the same direction of the lamp-post are considered.

From $\triangle$ ABD and $\triangle$ PQD we have AB/BD = PQ/QD
From $\triangle$ABC and $\triangle$ LMC we have AB/BC = LM/MC
Therefore BD/QD = AB/PQ = AB/LM since PQ = LM
= BC/MC= (BD-BC)/(QD-MC) = CD/(QD-MC)
Now length of the lamp-post AB= (BDxPQ)/QD= (BC x LM)/MC
Distance between tip of the shadows and the foot of the lamp-post are BC = (CDxMC)/(QD-MC) and BD = (CDxQD)/QD-MC)

Achievements of the ancient to modern Mathematics not only gave a scientific and technological leap but revolutionized the



AB - lamp-post - LM, PQ gnomons of equal height - BC, BD are the distance from the foot of the lamp-post to the tip of the shadows.
To find AB, BC, BD.

human thinkinig also. Euclidean geometry, for centuries the stock example of objective truth and incontestable knowledge, now seems merely the world seen through the spectacles of habit and not at all the necessary structure of reality. The philosophpy of four ancestors -

* The world presents to us an objective reality, which in principle we can know.

* There is about the world a unique set of truths which are objectively valid and mutually consistent.

* By the right choice of method these truths are discoverable - changed by the discovery of non-Euclidean geometry. After discovering hyperbolic geoemtry Bolayi in 1823 said: "From nothing I have created another wholly new world". Euclid never would have said this. It is significant to note that Ārybhaṭa has stated that the value of ð he uses is only an approximate value. The follow up work on ð also points to such a philosophical change.

So one can conclude that our ancient Mathematics was in the right direction and the methodology involved was highly intellectual and in no way second to any other civilization of that age. But one cannot be of the belief that ancient work contains everything and is on the supreme position. The foundation was very well set and the methodology and creativity must be well appreciated.

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Āryabhaṭīyabhāṣya

N.K.Sundareswaran

Āryabhaṭa was an intellectual giant who boldly challenged the wrong notions and beliefs held by society in which he lived. He is the first man in the known history of mankind to state that the earth rotates on its own imaginary axis. Today, a simile is told in the primary classes to teach the story of Earth's rotation on its own imaginary axis. It goes like this: To a man sitting in a moving boat all stationary things on the banks appear to move backwards. Actually the seer is moving and the things which are stationary appear to move. Likewise for us, sitting on the rotating earth, stars on the celestial sphere seem to go round us. This simile is Āyabhaṭa's. He says:

> अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् ।
> अचलानि भानि तद्वत्समपश्चिमगानि लङ्कायाम् ।।
>
> *(Āryabhaṭīya - Golapāda 9)*

His *Āryabhaṭīya* is the first Indian work dealing exclusively with Mathematics and Astronomy in a systematic manner. Strikingly predictive astrology does not find a place in this work. This small work containing 121 verses divided into four chapters is a collection of two compositions - *Daśagītikasūtra* and *Āryāṣṭaśata*. This epoch making work is written in sūtra style - a terse and pithy style warranting explanation. The work is also divided into four chapters, *Daśagītikāsūtra* being the first chapter. Also named as Gītikāpāda, the first chapter is a table of constants and parameters. The second chapter named

Gaṇitapāda deals with many subjects on Algebra, Arithmetics and Trigonometry. The third and fourth chapters (named Kālakriyāpāda and Goḷapāda respectively) deal with Astronomy proper. Sine table, evaluation of π to a very high degree of accuracy and the solution of first degree and indeterminate equations are Āryabhaṭa's notable mathematical contributions. Statement of theory of rotatian of the Earth, computation of eclipses and enunciation of diameters of planets are some of his notabie astronomical pronouncements. His statements like भूगोळ & सर्वतो वृत्ताः (Goḷapāda, 6- the Earth is a uniform sphere) and

भूग्रहभानां गोळार्धानि स्वच्छायया विवर्णानि।
अर्धानि यथासारं सूर्याभिमुखानि दीप्यन्ते।। (Goḷapāda,5)

are astonishing findings taking into consideration his date (b.476 AD). Naturally bold statements of theory of rotation of the Earth and implied refutation of Rāhu-Ketu story of eclipses provoked orthodox people. They vehemently opposed his unorthodox findings. Varāhamihira, a younger contemporary of Āryabhaṭa, who is well known for his intellectual honesty exhibited in *Pañcasiddhāntikā* refutes the theory of rotation of the Earth as follows:

भ्रमति भ्रमस्थितेव क्षितिरित्यपरे वदन्ति नोडुगणः।
यद्येवं श्येनाद्या न खात्स्वनिलयमाप्नुयुः।।
अन्यच्च भवेद्भूमेरह्ना भ्रमरंहसा ध्वजादीनां
नित्यं पश्चात्प्रेरणमथाल्पगा स्यात्कथं भ्रमति।।

(*Pañcasiddhāntikā* XIII 6-7)

[Others maintain that the Earth revolves as if it were placed on a revolving engine, and not the sphere; if that were the case, falcons and others (winged creatures) could not return from eather to their nests. And to mention another argument, if the Earth revolves in one day flags and other similar things would, owing to the quickness of revolution, stream constantly towards the west. On the other hand, if it moves slowly how does it revolve (once in 24 hours)]

In the same vein Lalla, a later scholar, asks:

यदिह भ्रमति क्षमा तदा स्वकुलायं कथमाप्नुयुः खगाः।
इषवोऽभिनभः समुज्झिता निपतन्तः स्युरपां पतेर्दिशि।।
पूर्वाभिमुखे भ्रमे भुवो वरुणाभिमुखो व्रजेद् घनः।
अथ मन्दगमात्तदा भवेत्कथमेकेन दिवा परिभ्रमः।।

(शिष्यधीवृद्धिदम्. मिथ्याध्यायः, 42-43)

Brahmagupta (b.598AD) quotes Āryabhaṭa's own text and refutes. He asks:

प्राणेनैति कलां भूर्यदि तर्हि कुतो व्रजेत्कमध्वानम्।
आवर्तनमुर्व्याश्चेन्न पतन्ति समुच्छ्रयाः कस्मात्।।

(Brahmasphuṭasiddhānta)

[If the earth moves through one minute of an arc in one respiration, from where does it starts its motion and where does it go? And if it rotates (on its own axis), why do tall and lofty objects not fall down?]

Unable to withstand the severe attack from scholars like Brahmagupta, later scholars rejected Āryabhaṭa's theory of rotation. And commentators of Āryabhaṭa themselves changed the reading of the text. Thus the statement प्राणेनैति कलां भूः (Gītikāpāda, 6) was changed as प्राणेनैति कलां भम् to mean that it is the stellar sphere which is rotating and not the Earth. Again the statement क्वावर्ताश्चापि नाक्षत्राः (Kālakriyāpāda, 5) was misread as भावर्ताश्चापि नाक्षत्राः. And the passage अनुलोमगतिर्नौस्थः etc (quoted above) was misinterpreted to mean that the stars moving along with the sphere towards west see the stationary objects situated at the equator of the earth as moving (towards east). The right interpretation is as follows:

Just as a man in a boat moving forward sees the stationary objects (on either sides of the river) as moving backward, just so are the stationary stars seen by the people at Laṅkā (on the

equator) as moving exactly towards the west.

Anyhow *Āryabhaṭīya* got wide popularity all over the country. The text was studied and commented upon by later scholars. Bhāskara-1 (AD 629) is the first known commentator of *Āryabhaṭīya*. *Mahābhāskarīya* is another work of Bhāskara which forms an elaborate exposition of astronomical aspects of *Āryabhaṭīya* and is often said to be a complementary to the latter text. Bhāskara's own *Laghubhāskarīya* is an abridged version of *Mahābhāskarīya*. Someśvara who is supposed to have lived between A.D 968 and 1200 in his commentary summarises Bhāskara's commentary. In a prefatory statement he says:

आचार्यार्यभटोक्तसूत्रविवृतिर्या भास्करेणोदिता
तस्याः सारतरं विकृष्य रचितं भाष्यं प्रकृष्टं लघु।

Sūryadevayajvan's (b.A.D.1191) commentary is an excellent exposition of *Āryabhaṭīya*. It is neither too discursive nor too terse. It is known by different names - Bhaṭaprakāśa, Prakāśa, Bhaṭaprakāśikā and Prakāśīkā. This commentary has been elucidated with further notes by Yallaya (A.D. 1480). Vaṭaśśeri Parameśvara's (15th century A.D) *Bhaṭadīpikā* commentary is brief but excellent which has *Prakāśikā* as its basis / model. Keḷallūr Nīlakaṇṭha Somayājī's (b.1444) commentary is an elaborate and extensive one.

Apart from these well known (published) commentaries, there are four other Sanskrit commentaries.They are of 1. Raghunātha (a king of Āndhra, 16th century), 2. Bhūtiviṣṇu (Tamilnadu), 3. Mādhava, a son of Virūpākṣa (Andhra) and of 4. Ghaṭīgopa (Kerala). (The last scholar has written two Malayalam commentaries also). Besides these noted Sanskrit commentaries, commentaries in regional languages like Malayalam, Telugu and Marathi also are available. Many works based on *Āryabhaṭīya* also came to be written. *Karaṇaratna* of Deva, *Śiṣyadhīvṛddhida* of Lalla, *Karaṇaprakāśikā* of Brahmadeva, *Bhaṭatulya* of Dāmodara are some such notable works.

Āryabhaṭīyabhāṣya of Keḷallūr Nīlakaṇṭha Somāyājī

When one says *Āryabhatīyabhāṣya* without any specification we can take it for granted that Keḷallūr Nīlakaṇṭha Somayājī's commentary is being referred to. It resembles the *Mahābhāṣya* of Patañjali. Elaborate and extensive in nature, it even points out the wrong interpretations of earlier scholars. Lucidity of expression and wealth of quotations and oral traditions are the notable features of the work. In a long colophonic statement given at the end of Gaṇitapāda the author designates the work as Mahābhāṣya and confidently claims of its special features. It goes as -

श्रीमदार्यभटाचार्यविरचितसिद्धान्तव्याख्याने महाभाष्ये उत्तरभागे युक्तिप्रतिपादनपरे त्यक्तान्यथाप्रतिपत्तौ निरस्तदुर्व्याख्याप्रपञ्चे समुद्घाटितगूढार्थे सकलजनपदजातमनुजहिते निदर्शितगीतिपादार्थे सर्वज्योतिषामयनरहस्यार्थनिदर्शके समुदाहृतमाधवादिगणितज्ञाचार्यकृतयुक्तिसमुदाये निरस्ताखिलविप्रतिपत्तिप्रपञ्चासमुपजनितसर्वज्योतिषामयनविदमलहृदयसरसिजविकासे निर्मले गम्भीरे अन्यूनानतिरिक्ते......

Even a cursory reader of *Bhāṣya* can see that this is not a tall claim made by Somayājī. Somayājī is the brilliant product of medieval Kerala School of Mathematics which is said to have done a tremendous work in the field of Infinite series.

Here it is proposed to focus the attention of the scholars to only one unique feature of *Bhāṣya*. And it is the critical approach of Somayājī, a prolific writer, time and again, explicitly states that Śāstra is not the final word and that it is subject to verification and correction. In fact, he states that śāstraic result should be subjected to periodical correction. In holding this view Somayājī is unparallelled in ancient and medieval India. He has written a separate work *(Jyotirmīmāmsā)* solely for stressing the point. He clearly states that the goal of 'Śāstra' itself is imparting knowledge of experimentation to students. (शिष्याणां ग्रहपरीक्षासामर्थ्यापादनमेव शास्त्रप्रयोजनम् - *Jyotirmīmāmsā,* p.8). Again in his *Bhāṣya* he points out that aim of the 'Śāstra' is to expound the rationale behind Mathematics and Spherics (गणितगोळयुक्तिप्रदर्शनपरमेवेदं शास्त्रम् - *Āryabhaṭīyabhāṣya* ,TSS.110, p.25). We can find a number of

such statements in his *Bhāṣya*. He is of the opinion that the results or exact values of the findings should not be explicitly stated since it may render a student complacent. He states:

युक्तयश्च तन्त्रकारैर्वक्तव्याः । न पुनरस्यैतावत्परिमाणमिति वक्तव्यम्। यदि तदुच्येत तर्हि शिष्याणां तेनैव कृतार्थता स्यात्। .... अतो युक्तय एव वक्तव्याः। (*TSS*.185, p.15).

Somayājī has commented only on *Āryāṣṭaśata* leaving out *Daśagītikāsūtra*. In the prefatory statement he says:

तत्रेयं त्रिपाद्यस्माभिर्व्याचिख्यासिता। यतस्तद्व्याख्येयरूपत्वाद् गीतिकापादस्य एतद्व्याख्यानेनैव अर्थः प्रकाशेत।

(By explaining *Āryāṣṭaśata*, naturally *Gītikā* also would be explained). *Gītikāpāda* or *Daśagītikāsūtra* is a collection of tables giving parameters. In fact, according to Somayājī Āryabhaṭa himself is not much interested in including the list of arrived at results in his Śāstra. He says:

गणितगोळयुक्तिप्रदर्शनपरमेवेदं शास्त्रम्। अत एव संख्याभागस्य पृथक्करणमिति............. (*TSS* 110, p.25)

At one instance Somayājī states that Āryabhaṭa got these parameters - the number of revolution of planets in a Mahāyuga etc- by way of experimentation. In fact, he puts it the other way round. Aryabhaṭa's excellence lies in experimentation and not due to any peculiarity of parameters.

"आर्यभटस्य परीक्षापरत्वादेव सकलदेशकालयोः स्फुटतरत्वम्। न पुनस्तदुक्तभगणादिवैशिष्ट्यात् " (*Jyotirmīmāmsā*, p.5)

Somayājī does not hesitate to point out that Āryabhaṭa's constants are also subject to correction. He does it with solid evidence. He cites two solar eclipses seen in Trivandrum and Haridar on Kali days 1681472 and 1686847 respectively which, if calculated with Āryabhaṭa's values, would not have been known at all.

He calls upon others also to observe celestial phenomena and to make periodical revision of parameters so that calculation tallies with the observed fact. He cites that the model of his grand teacher Vaṭaśśeri

Parameśvara who not only observed eclipses for a continuous period of 55 years but also recorded the collected data in his *Karmadīpikā*. A very important contribution of Somayājī in this regard is the long tract of verses given in the commentary on 'Parīkṣāsūtra' (Goḷapāda, verse 48) which is a practical guide for observation and verification of astronomical phenomena.

Thus in Somayājī we can find a unique Indian thinker - not of modern times - who openly and staunchly holds that 'śāstra', Jyotiśśāstra at least for that matter, is not the final word and is subject to verification and correction and that he upholds critical outlook which is the basis of Western scientific tradition.

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Tantrasaṅgraha

N. K. Sundareswaran

For a long time most of the Indologists held the view that after Bhaskara 11 of *Līlāvatī* fame, no original work was done in the twin disciplines of mathematics and astronomy in India. But it is now widely accepted that during the medieval times - a period roughly between 1350-1700 A.D - there flourished in Kerala, a School of astronomers which carried out significant and original work in the field starting with Saṅgamagrāma Mādhava (c. 1340-1425) and extending upto Acyuta Piṣāroṭi (c.1550-1621). This long unbroken tradition made important contribution to mathematical analysis much before the Subject was developed in Europe. Some significant discoveries of this school are (1) the development of Gregory series for inverse tangent, (2) the Leibnitz series, (3) Newton's power series for sine and cosine and (4) Taylor's series for approximation for sine & cosine functions. The *Tantrasaṅgraha* (*TS*) of Nīlakaṇṭha Somayājī is one of the brilliant works of this school.

Nīlakaṇṭha Somayājī, who is known to have born on the 14th June of 1444 A.D (He gives this date in one of his works viz. *Siddhāntadarpaṇavyākhyā*, by the Kali chronogram "tyajāmyajñatām tarkaiḥ" (Kali day 1660181) is well known for his elaborate commentary on *Āryabhaṭīya*. Besides these two major works (*TS* and *Āryabhaṭīyabhāṣya*) he has also authored some minor works on Astronomy. They are *Jyotirmīmīmsā, Siddhāntadarpaṇa* (with an auto commentary), *Candracchāyāgaṇita, Goḷasāra, Grahaṇanirṇaya* and

Sundararājapraśnottara. The last two works are not yet discovered. Among his minor works *Jyotirmīmāmsā* carries much importance since its sole aim is to stress on the importance of periodical revisions on astronomical parameters based on constant observations and investigations. Among the commentaries on *Āryabhaṭīya*, Somayājī's commentary assumes importance for its lucidity of expression and wealth of quotations. It is aptly christened as Mahābhāṣya by the author. In these two works, ie. *TS* and *Āryabhaṭīyabhāṣya*, Somayājī has preserved many mathematical findings and rationales. He gives three sets of astronomical parameters in his three works, viz. *TS*, *Siddhāntadarpaṇa* and *Goḷasārs*. From a long colophonic passage given in his *Āryabhaṭīyabhāṣya*, it is learnt that he belonged to Śrīkuṇḍagrāma (Tṛkkaṇṭiyūr near Tirūr) and was a member of Keralasadgrāma (the Sanskritised form of Keḷallūr which is sometimes said as Keḷannur) family. He belonged to Gargagotra and was a follower of Āśvalāyanasūtra. He had performed somayāga. His favourite deity was Parameśvara of Tṛppraṅṅoḍ. He was initiated into astronomy by Dāmodara, son of Parameśvara who in turn was the author of *Dṛggaṇita*. He was initiated into Vedānta by Ravi. His father's name was Jātadeva. He had a younger brother Śaṅkara and a close associate Subrahmaṇya.

An astronomical work belonging to Tantra class, *TS* contains 432 verses and is divided into 8 chapters. A Tantra work- which usually takes the commencement of current Kaliyuga as the starting point for computations - has the freedom to choose the topics of special interest and elaborate them according to the wish of the author. Here in this text the first chapter deals with the calculation of mean planets. The conception of time, the calculation of past Kali days, the seasons and the solar and the lunar months are described in about forty verses. The second chapter in eighty verses deals with the calculation of mean solar day and the determination of orbits of planets in the geometric system. The third chapter is the longest one. It deals in 118 verses with the fixing of gnomon and calculation of equator, meridian, latitude, declination etc. by gnomonic shadow. There are many illustrations and mathematical problems pertaining to

gnomon and its shadow. The fourth and fifth chapters deal with lunar and solar eclipses respectively. The sixth chapter deals with vyatīpāta. Vyatīpāta denotes the duration when the sum of longitudes of the sun and the moon equals 180 degree or 360 degree. The seventh chapter deals with Reduction to observation. And the last chapter deals with elongation of Moon's cusps.

The work has got two commentaries written by Tṛkkuṭaveli Śaṅkara Vāriyar (c.1500-1560). One is in prose and the other in verse. The first is named as *Laghuvivṛti*[2] and the other goes by the name *Yuktidīpikā*[3]. The second one extends only upto the end of the fourth chapter. The author is a direct disciple of Somayājī.

According to Śaṅkara Vāriyar, the first and last verses of the work contain the chronograms of date of commencement and completion of the work. These two chronograms "he viṣṇo nihitam kṛtsnam' and "lakṣmīśanihitadhyāna" correspond to the 22nd and 27th of March 1500 A.D.

TS carries much importance for two reasons. One is that it preserves some findings of medievel Kerala mathematics. And the other is that Somayājī gives a revised planetary model for interior planets Venus and Mercury. Let us first discuss the historical importance of the text. The text attracted the attention of scholars because (1) it, along with three later works viz. *Yuktibhāṣā, Yuktidīpikā* and *Karaṇapaddhati,* form the sole record of the significant findings made by the great Mathematician Saṅgamagrāma Mādhava and (2) it forms the basis and model for *Yuktibhāṣa*, a work written in Malayalam which is a unique text in Indian mathematics giving rationales for the mathamatical findings that are dealt with. The first scholar to recognise the significant contributions made by the above said works was Charles M. Whish. He presented a paper on the Hindu quadrature of the circle and the infinite series of the proportion of circumference and diameter exhibited in the four śāstras - *Tantrasaṅgraha, Yuktibhāṣa, Karaṇapaddhati and Sadratnamālā* before the Royal Asiatic Society in 1832. Unfortunately there was nobody to take up seriously the

investigation started by Whish for a century. In 1940-s a team of Indian scholars lead by Prof.C. T. Rajagopal launched a detailed study on the discoveries of Whish. The edition of the first part of *Tantrasaṅgraha* with expository notes made by Ramavarma Maru Thampuran and A.R.Akhileswara Iyer came out in 1948. The first edition of *Tantrasaṅgraha* with the *Laghuvivṛti* commentary came out in 1958. The editors of *Yuktibhāṣa,* made use of a manuscript of a commentary on *Tantrasaṅgraha* for preparing their expository notes.Their failure to disitnguish the text from the commentary gave way for a confusion. Many verses of this commentary were quoted by them as belonging to *TS*. This created an impression that the text as edited in Trivandrum Sanskrit Series is either incomplete or is only a compressed version of the original, which is yet to be discovered. This confusion was cleared by the edition of the said commentary made by K.V Sarma in 1977. Sarma established that *TS* contained 432 verses only, as is given in the Trivandrum edition. In support of this he cites a colophonic statement appearing in the Manuscript No.C.224 C of Kerala University Oriental Research and Manuscripys Library. The statement runs as follows:

"iti tantrasaṅgrahe aṣṭamo' dhyāyaḥ / tantrasaṅgrahaḥ samāptaḥ / adhyāyam eṭṭilum kūṭi ślokaṅṅal nānūṭṭi muppatti raṇṭu"

(Thus ends the eighth chapter in *Tantrasaṅgraha*. Here ends *Tantrasaṅgraha*. There are 432 verses contained in eight chapters.)

Thus some findings, wrongly traced to *TS* actually belonged to the commentary *Yuktidipīkā*. For example, the verses giving Newton's power series for sines and cosines:

$$\sin X = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \ldots$$

$$\cos X = 1 \quad \frac{x^2}{2!} + \frac{x^4}{4!} + \frac{x^6}{6!} \ldots$$

"nihatya cāpavargeṇa" etc. (*Yuktibhāṣa* Ed. Akhileswara Iyer, p.90)actually belong to *Yuktidīpikā*. The same verses appear in

Karaṇapaddhati (of Putumana Somayājī) also. Though positive proofs are still wanting about the authorship of these verses, K.V.Sarma observes that it is very likely that Saṅgamagrāma Mādhava is the author.[4]

However, there are some of other quotations of Mādhava in *TS*. One such quotation gives Taylor's series for sine and cosine functions. Brook Taylor (1685-1731 A.D.) gives an approximation for sine and cosine functions upto the second power of small quantities. It may be expressed as

$$f(x+\theta)= f(x)+\theta f(x) + \frac{\theta^2}{2!} f(x) + \ldots.$$

when θ is small

This approximation in particular cases f(x) = sin x and f(x) = cos x has been anticipated by Mādhava, more than 300 years before Taylor. *TS* quotes the verses of Mādhava which run as follows:

इष्टदोःकोटिधनुषोः स्वसमीपसमीरिते।
ज्ये द्वे सावयवेऽन्यस्य कुर्यादूनाधिकं धनुः।।
द्विघ्नतल्लिप्तिकाप्तैकशरशैलशिखीन्दवः।
न्यस्याच्छेदाय च मिथस्तत्संस्कारविधित्सया।।
छित्वैकां प्रक्षिपेज्जह्यात्तद्धनुष्यधिकोनके।
अन्यस्यामथ तां द्विघ्नां तथा स्यामिति संस्कृतिः।
इति ते कृतसंस्कारे स्वगुणौ धनुषोस्तयोः।।   (II.10 - 14)

Immediately following this, another verse of Mādhava is quoted which gives the trigonometric identities.

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

The verse runs thus:

जीवे परस्परनिजेतरमौर्विकाभ्या-
मभ्यस्य विस्तृतिदलेन विभाज्यमाने।

अन्योन्ययोगविरहानुगुणे भवेतां
यद्वा स्वलम्बकृतभेदपदीकृते द्वे।। (II.16)

The fact that some quotations of Saṅgamagrāma Mādhava ascribed to *TS* actually do not belong to it does not diminish the importance of the work from the historical point of view. All such quotations are to be traced to *Yuktidīpikā* commentary of the work. The author of *Yuktidīpikā* is a direct disciple of Somayājī. He, in the colophonic passage given at the end of each chapter, states that his is an interpretation of *Tantrasaṅgraha* according to the author of *Yuktibhāṣa*. Hence all the works are interconnected. They belong to the same tradition. Probably Somayājī and his predecessor and grand teacher Vaṭaśśeri Parameśvara are the sources of inspiration for Śaṅkara Vāriyar, Jyeṣṭhadeva (the author of *Yuktibhāṣa*), Putumana Somayājī etc. to record the rationales of the derived results. In this connection, it may be remembered that Parameśvara, a profuse writer on astronomy has recorded the astronomical data collected by him by way of observing the celestial phenomena like eclipses for a continuous period of 55 years (in his commentary on *Govindasvāmibhāṣya*)

Now let us take up the next point, viz. the revision of planetary model. In ancient Indian tradition, the procedure for calculating the geocentric longitude of five planets Mercury, Venus, Mars, Jupiter and Saturn had three steps. First one is the calculation of mean position of the planet. This is obtained by multiplying mean civil days elapsed since the epoch by mean daily motion of the planet. Then a correction called mandasamskāra is applied to this. Mandasamskāra or equation of centre goes to make up the error caused by the eccentricity of planetary motion. The manda corrected mean longtitude is called mandasphuṭagraha. And lastly a second correction called śīghra samskāra is applied to mandasphuṭagraha. This goes to convert the heliocentric longtitude to a geocentric one. Right from Āryabhaṭa's time, for the inferior planets, ie., Mercury and Venus the manda correction was applied to the mean Sun instead of the heliocentric planet. For exterior planets it was applied

to mean heliocentric planet only. This caused some error in the inferior planets. It was Nīlakaṇṭha Somayājī who enunciated for the first time in the history of astronomy that manda correction should be applied to mean heliocentric planet itself for inferior planets also.[5] This he specifies in his works *Golasāra, Siddhāntadarpaṇa, Āryabhatīyabhāṣya* and *TS. TS* is thus said to give a geometric planetary model, in which all the five planets Mercury, Venus, Mars, Jupiter and Saturn move in eccentric orbits around the sun which in turn goes round the earth.

Thus *TS* forms an excellent product of the great School of medieval Kerala mathematicians. The reasons which contributed to the cessation of such a highly creative and critical mathematical activity in central Kerala is worth probing into.

References

1. For details see *A History of Kerala School of Hindu Astronomy,* K.V. Sarma, Chapter II
2. Published in Trivandrum Sanskrit Series, No 188.
3. Ed. K.V. Sarma, Hoshiarpur, 1977.
4. Sarma, *Op.cit,* p.18
5. For details see "Modification of the earlier Indian Planetary Theory by Kerala Astronomers and the implied heliocentric picture of planetary Motion", K.Rama Subramanian, M.D.Srinivasa & M.S.Sriram, *Current Science,* vol.66, no.10, 25 May 1994.



Jyotirmīmāmsā

K. Sekharan

The *Jyotirmīmāmsā (JM)* of Keḷallūr Nīlakaṇṭha Somayājī (A.D. 1444-1545) is a basic and one of the most authoritative works on Indian astronomy produced in Kerala. It is an excellent work on Indian methodology of science relating to astronomical theory and practice.

Prof.K.V. Sarma, the editor of the book has critically examined the manuscript and identified the name of the work as Jyotirmīmāmsā and its author as Nīlakaṇṭha Somayājī.

JM is a comparatively small treatise on Indian astronomy. Its importance lies in the exposition of hither-to- unknown methods of scientific investigations. It also casually refers to the most controversial views regarding the Indian origin of science. It sheds much light on the importance of observation and experiments and counters many arguments of spiritual origination of Indian science.

After examining the views of his predecessors Nīlakaṇṭha deviates from the traditional views regarding Indian astronomical theories. He is not willing to follow blindly the views of earlier astronomers on the origin and development of Indian astronomy. As observed by Prof. K.V. Sarma, Nīlakaṇṭha takes astronomy primarily as a practical discipline based on experimentation and observation. Somayājī insists that the results arrived at by computation should tally with observation and that astronomical

parameters and other constants should be revised periodically towards this purpose (K.V. Sarma, p.9)

The earlier astronomers insist that the occurrences of the planetary revolutions should be computed as it was instructed by Āryabhaṭa and the number of planetary revolutions given by Āryabhaṭa are immutable because they form the part of 'divine instruction'. Here Nīlakaṇṭha argues that the expression 'divine instruction' does not mean any direct instruction by the Gods, but only the chastening of the intellect through divine grace (देवताप्रसादो मतिवेमल्यहेतुरेव), as a result of which the authors could express their thoughts logically (*JM*, pp.2-3). Nīlakaṇṭha refutes the views of earlier interpreters of Āryabhaṭa by bringing the real sense of Āryabhaṭa's statement within the sphere of 'arthavāda'.

Nīlakaṇṭha emphasises that computation and revision of the rotations of the planets be made by means of observation and logical inference. The revolutions of bhagaṇa (भगण), ucca (उच्च), pāta (पात) etc. are usually used for computation of planets. Somayājī advises that the authority of those revolutions can be verified by means of observation at the time of eclipses. If it does not tally with observation, he says, experiments should be conducted with instruments. In support of this he instructs: - ये पुनरन्यथा प्राक्तनसिद्धान्तस्य भेदे सति यन्त्रैः परीक्ष्य ग्रहाणां भगणादिसंख्यां ज्ञात्वा अभिनवसिद्धान्तः प्रणेयः इत्यर्थात्। तत्ते इहलोके अहसनीयाः परलोके अदण्डनीयाश्च। (p.6 - If the contemporary experiment does not reconcile with the earlier systems formulated for the computation of the revolution numbers of the planets he should conduct experiments with instruments and ascertain the actual number of revolutions thereby. An entirely different new system has thus to be expounded and therefore he will neither be rediculed for this in this world nor punished in the next.)

Thus Nīlakaṇṭha insists for the necessity of periodical revision of planetary parameters. He has presented some instances of

such corrections propounded to the parameters of Āryabhaṭa by certain astronomers including Haridatta, Govinda, Brahmagupta and Lalla (pp.10-12)

It is very interesting and admirable that Nīlakaṇṭha pays more attention to the interpretations on some dates of revisions mentioned in *Āryabhaṭīya*. He interferes into the interpretations by Haridatta and Lalla on the 10th verse of *Kālakriyāpāda* in *Āryabhaṭīya* and establishes his own opinion with a critical and logical perception, justifying the interpretation by Lalla. (See *JM*, pp.13-14). The relevant verse in *Āryabhaṭīya* is the following:

षष्ट्यब्दानां षष्टिर्यदा व्यतीतास्त्रयश्च युगपादाः।
त्र्यधिका विंशतिशब्दास्तदेह मम जन्मनोऽतीताः।।

Basically *Jyotirmīmāmsā* is not only a work describing the practices of Indian astronomers but a basic text on astronomical science also. Nīlakaṇṭha has high regards for astronomers. He quotes Varāhamihira to show the respectability of astronomers as follows:-

सिद्धान्तभेदेऽप्ययननिवृत्तौ सममण्डललोखासंप्रयोगाभ्युदितांशकानां च छायायन्त्रदृग्गणितसाम्येन प्रतिपादनकुशलः, सूर्यादीनां च ग्रहाणां शीघ्रमन्दनीचोच्चयाम्योत्तरगतिकारणाभिज्ञः, सूर्याचन्द्रमसोश्च ग्रहणे प्रग्रहविमोक्षदेशकालवित्, अनागतानां च ग्रहयुद्धसमागमानामादेष्टा इति । (p.7)

Eventhough Nīlakaṇṭha is most posterior in the long line of astronomers he has great regards for the methods of experiments and observation for which Āryabhaṭan system strongly advocates. He is a staunch follower of Āryabhaṭa and never agrees with arguments that refute the findings of Āryabhaṭa. He says:

तद्युक्तिरपि आर्यभटीयान्तर्भूतैव । या काचित् कस्यचित् युक्तिः
कर्म वा सम्भवेत्, क्वचित् सर्वं सूचितं सर्वयुक्तिनिधिना (आर्यभटेन) ।
(pp.40-41)-

All principles formulated in computing the motion of planets are implied in the *Āryabhaṭīya*. Whatever be the principle or method

Sadratnamālā

N.V.P. Unithiri

The paper presented by Charls M. Whish at Royal Asiatic Society in 1832, which has introduced astronomy and mathematics of medieval Kerala to the international scholars for the first time, has included *Sadratnamālā* (Gemset necklace) by Katathanad Śaṅkara Varmā (1774 -1839), popularly known as Onchiyil Appu Thampuran, among the four such works. Almost all the doctrines of the astronomy and mathematics in Kerala are summarized in *Sadratanamālā* and thus in it we have got an excellent example of a handbook of Kerala School of astronomy and mathematics. This book, though incompletely, was published in 1898[1]. The author Śaṅkara Varmā himself has written a Malayalam commentary on the work. It is available only up to the verse 6.32.

Sadratnamālā contains six chapters called prakaraṇas. The first chapter is named as *Parikarmāṣṭakaprakaraṇa* (the chapter on the eight logistics). This chapter begins with four introductory verses. In the first of them the author salutes the lotus-feet of Goddess Pārvatī, the deity of Lokamalayārkāvu (Lokanārkāvu), his preceptors in general, Aruṇa (Sun) etc. The second verse extends salutation to the Brahmin scholars, by whose grace the author wishes to be devoid of faults and be with all the best. In the next verse, Śaṅkara Varmā remembers his elder brother Rāma Varmā, the younger brother of King Udaya Varmā. The last among them expresses the author's humility.

Then in a couple of verses, the author gives the names of the decimal numerals, namely, eka (one), daśa (ten), śata (hundred), sahasra (thousand), ayuta (ten thousand), niyuta (lakh), prayuta (ten lakhs), koṭi (crore), arbuda (ten crores), vṛnda (hundred crores), kharva (thousand hundred crores), nikharva (ten thousand hundred coroes), mahāpadma (one lakh hundred crores), śaṅku *or* śaṅkha (ten hundred crores), vāridhi (one crore hundred crores), antya (ten crores hundred crores), madhya (thousand crores hundred crores), and parārdha (ten thousand crores hundred crores).

Definition of the eight logistics (parikarmāṣṭaka) follow this. Yuti (addition), *viyuti* (subtraction), guṇana (multiplication), haraṇa (division), varga (square), vargamūla (square root), ghana (cube) and ghanamūla (cube root) are the eight logistics. The process of all these logistics is described in detail in eleven verses.

Bhaskara II (12th century A.D) deals all this with in the first section of the *Līlāvatī* part of *Siddhāntaśiromaṇi.*

Thus the first chapter has nineteen verses in total.

Chapter II is called *paribhāṣāprakaraṇa* (the chapter on the technical terms). Here we have the enumeration of different measures. Measure of time, technical terms of the parts of jyotiścakra or rāśicakra (zodiac) and the presence of stars in it, the nature of tithi (the time taken by the elongation of the moon to increase by 12^0 starting from zero) and the names of planets and stars are dealt with. This is followed by a description of the pañāṅāga (almanac). Measure of length, grains and weight is the next topic. Then the names and measure of money are taken into account. Niṣkā, dramma, paṇa, kākiṇī and varāṭaka are the names of money. Lastly architectural formula for orientation of directions is described. The matters dealt with in this chapter also can be seen in the first section of *Līlāvatī*. The second chapter contains fourteen verses in total.

Chapter III is called *Pañcāṅgaprakaraṇa* (the chapter on five astronomical limbs). It begins with the invoacation of Gaṇapati,

Sarasvatī, Kṛṣṇa, Subrahmaṇya, planets like Sun, the author's preceptors, Śrīlokāmbā and Dakṣiṇāmūrti. Then the definition of the multi-purposeful trairāśika (rule of three) is given. The rule of kaṭapayādi, a kind of syllabic numeration, is the next topic. The relevant verse runs as follows:

> नञावचश्च शून्यानि, सङ्ख्याः कटपयादयः ।
> मिश्रे तूपान्त्यहल्सङ्ख्या, न च चिन्त्यो हलस्वरः ।। (III.3)

The syllables na, ña and vowels denote zero; ka ṭa pa ya etc. denote numerals. In the case of conjunct letters, the penultimate consonant syllable is to be counted. A consonant that is not connected with a vowel (k, l, n, r, etc.) can neither be treated as a number nor as zero.[2]

How to calculate the Kali year is then dealt with. The computation of mean Sun, ahargaṇa (number of days elapsed from the beginning of the aeon), true Sun, true moon, lunar day, yoga (the time which elapses when the sum of longitudes of the Sun and the Moon to increase by 13 10/3 starting from zero), zodiacs, nakṣatrapādas (quarters of asterisms) and karaṇas (half of the duration of a tithi), are described . At last, the author states the methods for ascertaining the time elapsed after sunrise and sunset. The total verses in chapter III are twenty-one.

Chapter IV is named *Jyācāpādiprakaraṇa* (the chapter on arcs, sines, etc.). This chapter deals with arcs and sines and their application in astronomical measurements and computations. How to determine the circumference of a circle is the first topic dealt with here. Next we have the formula to derive the sines. Then the author deals with the derivation of arcs and corresponding sines and allied topics. Kendra (centre) and pādas (quarters) are treated next. This is followed by the description of derivation of arc and making sines. Paramakrānti (obliquity of the ecliptic to 24^{0}) and krānti (declination of a point on the ecliptic) in given time are then dealt with. Next the author has taken up the treatment of prāṇakalāntara (a minute of angle). How to make different kinds of figures like square is the following topic. The definition of gnomon and related computations are then dealt with.

Next we see how to derive terrestrial latitude in parahita and dṛk systems. The following topic is the computation of palāṅgula in different places. Then we have the derivation of latitude and longitude. Subsequently, the derivation of carajyā (sine of the arc), cara, bhūjyā (sine measured in the diurnal circle corresponding to the carajyā), hārajyā and lambajyā (cosine of the latitude) is dealt with. Next we see how to make east-west line by the shadow of the Sun. This is followed by the derivation of deśāntara, deśāntarakāla and allied matters.Then the author deals with the measure of zodiac and that of the zodiac of the day. Nāḍikaraṇa (the calculation in respect of nāḍikās and vināḍikās) is the subject matter dealt with next. Then we have the derivation of udayalagna (the rising rāśi, an arc equal to 30^{0}). This is followed by the discussion of different sines, namely jyā (sine), koṭi (cosine), spṛgjyā (tangent), kuspṛgjyā (contangent), chedijyā (secant) and kucchedijyā (cosecant). This chapter contains 43 verses in total.

Chapter V is the longest one, which is called *Pañcabodha-prakaraṇa* (the chapter comprising five sections).The five sections are on chāyā (shadow), *grahaṇa* (eclipse), cakrārdha or vyatīpāta (the phenomenon due to adversary effect that the Sun and the Moon face in their northward motion), mauḍhya (the condition of the planets except the Sun when they reach near by the Sun) and śṛṅgonnati (elevation of the cusps of the crescent Moon). The chapter begins with the enumeration of these names. Then the calculations in connection with the derivation of kālalagna are dealt with. Next the author shows how to derive the shadows of the Sun. Finding out the time out of the shadow of the given time is the subject matter then dealt with. The next topic is the derivation of palāṅgula. To bring out śaṅkvagra (the tip of the gnomon) and arkāgra (the tip of the Sun) is treated then. This is followed by the computation of samaśaṅku (cosine of the altitude when the Sun is on the Prime Vertical) and of the true Sun by samaśaṅku. Then it is stated how to calculate true Sun by shadow of the noon.

Next the author discusses the calculations relating to the shadow of the Moon (*Candracchāyāgaṇita).* First the derivation of the true Moon is dealt with. Then comes the derivation of the Moon's great shadow.

In the next verse, how to bring out the shadow of the Moon is dealt with. Calculation of the proposed time through the shadow of the Moon is discussed next. Vaṭaśśeri Parameśvaran Namboodiri (1360-1455) treats the same topic in his *Candracchāyāgaṇita*. Tṛkkaṇṭiyūr Acyuta Piṣāroṭi (1550-1621) also deals this with in his *Chāyāṣṭaka* and *Candracchāyāgaṇitavyākhyā*.

Computation of eclipses is the next topic. The process of eclipses is generally described first. What is the difference between the eclipses of the Sun and the Moon is stated then. The following topic is the derivation of the diametric liptās (minutes of arc) of the images of the Sun, Moon and the earth. The calculation of natiliptās (liptās related to the parallax in latitude) is then dealt with. Next we have the calculation of the vikṣepa (celestial latitude) of the Moon. Iṣṭagrāsa (the computation of the extent of the eclipse in given time and space) is the subject matter treated next. Then the author discusses the derivation of sthityardhas (the approximate halves of the position of the Sun and the Moon at the time of eclipses). The computation of valana (deviation of direction) is dealt with next. Lastly, the author states how to make the eclipses in black and white. Vaṭaśśeri Parameśvaran Namboodiri, Keḷallūr Nīlakaṇṭha Somayājī (1444-1545) and Tṛkkaṇṭiyūr Acyuta Piṣāroṭi deal all these matters with in their works on eclipses, namely, *Grahaṇāṣṭaka, Grahaṇamaṇḍana* and *Grahaṇanyāyadīpikā; Grahaṇanirṇaya;* and *Uparāgakriyākrama* and *Uparāgaviṁśati*.

Next comes the calculation of vyatīpāta. Vyatīpāta is of two kinds - lāṭa and vāīdhṛta. Computation of vyatīpāta and the nature and auspiciousness thereof are then dealt with. Vaṭaśśeri Parameśvaran Namboodiri treats the same topic in his *Vyatīpātāṣṭakavyākhyā*. At the end of the section, Śaṅkara Varmā points out the difference in regard to the above phenomenon in parahita and dṛg systems. Then the process of vyatīpāta is described in some detail.

Calculation of mauḍhya of the planets is the theme discussed after the topic of vyatīpāta.

Then the author takes up the computation of śṛṅgonnati (elevation of the horns of the Moon).

Previous authors, especially Keralites, had already dealt with all the matters discussed in *Sadratnamālā*. We have mentioned some of them. The others include the following: Saṅgamagrāma Mādhava's *Veṇvāroha*, which states many things regarding the position of the Moon; *Mahājyānayanaprakāra, Madhyamānayanaprakāra*, both by Saṅgamagrāma Mādhava, which put forward a number of novel theories; Vaṭaśśeri Parameśvaran Namboodiri's *Siddhāntadīpikā*; Keḷallūr Nīlakaṇṭha Somayājī's *Tantrasaṅgraha* and *Siddhāntadarpaṇa;* and Tṛkkaṇṭiyūr Acyuta Piṣāroṭi's *Sphuṭanirṇaya*.

Chapter V contains fifty-one verses, the last of which is an invocation to the Goddess of Lokanārkāvu, the author's family deity.

Chapter VI is called *Gaṇitapariṣkaraṇa* (the chapter on the periodical revision of astronomical computations). In a Malayalam work by name *Dṛkkaraṇa*, ascribed to Jyeṣṭhadeva, we have a similar account. First, Śaṅkara Varmā discusses the calculations made by Āryabhaṭa. The first two verses state the rotation of the earth and other theories promulgated by the great astronomer. Then he gives us an idea of the methodology of the parahita system. The revision made by Haradatta (650-700 A.D.), the founder of the *parahita* system, is known as śakābdasamskāra or bhaṭābdasamskāra, which is the subject matter taken up by the author next. Then we have the description of the *uccas* (higher apses and ascending node) of the planets. This is followed by the treatment of manda and ucca circumferences of the planets. Derivation of the the sphuṭaparidhis (true circumferences) of the planets is the subject matter dealt with next. Then comes the calculation of the accurate circumferences of the Sun and Moon. After this, the author discusses the derivation of the jyās (arcs) of mṛga, karki, etc. for kuja (Mars). Computation of the true circumference out of given arc of the given planet is dealt with next. How to know the true circumferences of the arcs of mṛga, karki, etc. is the theme that is treated then. Another device for the same is also presented. This is followed

by the derivation of spuṭa of all the planets. Then the author deals with the calculation of madhyabhogaliptās of the planets for a day out of their own gati. Derivation of sphuṭagati of Mars, etc., in given time is described then. Computation of the madhyama (mean) of the Sun for the time of sphuṭasamkrānti[3] is the subject matter next dealt with. Then we have the method to know how many days the sun stands in zodiacs like Meṣa and in the asterisms like *Aśvinī*. After this, the author states the formula for the calculation of one year and the formulae for the calculations of the samkrāntis of zodiacs, stars and year. The derivation of yogyādivākya (formula to compute the yogya, etc.) is dealt with next. Calculation of the accurate time of the entrance of the Sun into each zodiac is the subject matter that is discussed next. How to compute the days and months of the Sun and the Moon is then described. This is followed by the derivation of the kakṣyās (orbital circles) of the planets. Then the author states the diameters of the Sun, Moon and the earth as perscribed in previous books. The next topic is the computation of the movements of the Sun etc., in relation to distance. How to determine the diameters of the earth is the subject matter that follows. Calculation of the circumference of the earth is described next. Then the derivation of the radius of the orbital circle of the Sun is dealt with.

The Malayalam commentary written by Śaṅkara Varmā himself is available only up to this, i.e., verse 6.32. The description of the revision according to parahita system continues in two more verses. Thus, in this section of *Sadratnamālā*, we have a comprehensive account of the astronomical revision accroding to parahita system as made out by Haradatta (650-700) in his *Grahacāranibandhana*. Then the author takes up the periodical revision according to the dṛg system. The verses 43-54 are devoted for this purpose. It is Vaṭaśśeri Parameśvaran Namboodiri who propounded the dṛg system in his monumental treatise, *Dṛggaṇita*. Here Śaṅkara Varmā follows this work. Then he puts forward a device for the astronomical revision in general. Next, the author gives the date of the composition of the book. It is the Kali year 4921 corresponding to 1819 A.D. With two more verses indicating the fame of the work, *Sadratnamālā* comes to a close.

The foregoing content analysis of *Sadratnamālā* reveals that it summarizes almost all the matters that were dealt with by previous Kerala authors of astronomy and mathematics. The treatise occupies, in this way, a prominent place in the field of astronomy and mathematics, just as *Kāvyaprakāśa* and *Siddhāntakaumudī* do have in Poetics and Grammar, respectively. It can, therefore, be concluded that *Sadratnamālā* is very much useful for the beginners in the field of astronomy and mathematics in ancient and medieval India in general and Kerala in particular.

References

1 Kavanodayam, Nadapuram, Calicut.

2. Anand Raman, Department of Computer Science, Massey University, New Zealand, in his article, "The Ancient Kaṭapayādi Formula and the Modern Hashing Method", refers to this verse in *Sadratnamālā*. In this paper, he tries to establish that the kaṭapayādi system is an anticipation of the modern Hashing technique.

3. Saṃkrānti or samkramaṇa denotes the point of time when the Sun enters from one to another of the twelve rāśis.



Gaṇitaprakāśikā

E. Sreedharan

Gaṇitaprakāśikā (*GP*) of K.V.A. Rāma Poduvāḷ is a book dealing with astronmical calculations. It is a hand book for the astronomers to calculate the true longitudes of the planets, eclipses etc and also stands as a basic text for the preparation of almanacs or pañcāṅgas. The book is published in 1950 AD from the Deśamitram Printing and Publishing company Ltd., Kaṇṇūr. The text is printed in Malayalam script, but the contents are explained in Sanskrit verses. The author himself wrote a commentary named *Karaṇadīpikā*. It is a karaṇa text and the karaṇārambha accepted here is Ist mēṣa 1074 (13.4.1899). The Kalidina in the karaṇārambha is 182692. The calculations in the book are prepared according to the śuddhadṛggaṇita system. The author accepts principal value numbers from the modern astronomy and corrects them as per Indian method.

The gaṇita literature can be divided into three main divisions - siddhānta, tantra and karaṇa. The siddhānta, mainly consists of the science of mathematics, which measures madhyamas and the ahargaṇas for a kalpa. The total days between the kalpakāla and the intented date are called ahargaṇas. By multiplying the average motion of planets for a day with the ahargaṇa, we get the mean position of the planets. The tantra type of literature takes the beginning of Kalidina. The madhyamas of the planets at the beginning of the first Kali day are called kṣepakas. By calculating the

mean motion of the planets upto the intented date from the first Kaliday, the astronomer adjusts it into the kṣepakas. It becomes mean longitudes or madhyamas of the planets at the intented date. The majority of the books are of karaṇa type. This class also takes a cut of date, which is called karaṇārambha. In the tantra class, cut of date is fixed to the first Kali day, but in the karaṇa class it differs. For example, *GP* accepts 13.4.1899, while *Śuddhadṛggaṇita* accepts 15.8.1947 as the cut of date. After calculating the mean motion of the planets, upto the intented date from the cut of date the astronomer adjusts it into the kṣepaka. The result becomes the mean longitude of the planets at the intented date.

Kerala astronomers followed four systems for calculating their almanacs - Āryabhaṭan, parahita, dṛk, and śuddhadṛk systems. The last one is the latest and it is the most accurate one . The first book in North Kerala adopting this system is *GP*. Almost at the same time, *Gaṇitanirṇaya of* P.S. Puruṣottaman Namboodiri was published. After the publication of these books, almost all the astrologers of Kerala, followed the śuddhadṛk system only.

Author

Keḷoth Vāccākkara Āniṭil Rāman Eḷuttacchan is the author of *GP*. He was born in Payyannur, the exact location was Keḷoth, two kilometers west of present Payyannur busstand. Later, he shifted his residence to Annūr. This house is close to the Viṣṇu temple in Annūr.

Rāma Poduval was born in 1881 AD. His teachers are Śrīkaṇṭha, Karippat Kammāran Eḷuttacchan, Kunhirāman Eḷuttacchan, Cūvāṭṭa Cinḍan Eḷuttacchan, Uttamantil Eḷuttaccan and Kaṇḍampat Raman Eḷuttaccan. His parents were Ciriyakunhi Amma and Kunhampu Poduvāḷ. He married Kōḍi Amma, who belongs to the family named Kalliḍil Padiṇṇārekkara. He had three sons and two daughters named Govindan, Kṛṣṇan, Kunhirāman, Devi and Lakṣmi. The youngest daughter still lives at Annūr.

During his astrological practice at Karnataka, he met a scholar named Sūryanāṛāyaṇappa. This scholar gave him inspiration to write

GP. Then he watched the sky for astronomical studies for over twenty years. He was a widely read man, having mastery over astronomy. His teacher's professional experiences, his contact with Sūryanārāyaṇappa, the presence of sincere and loving disciples like V.P.K. Poduvāḷ and his personal experience helped him in writing GP.

GP is the only available book of Rama Poduval. He states in GP his intention to write another book, *Grahagaṇitakoṣṭhakam*. But there is no evidence for that he wrote the same. He died in 1959 at the age of seventy eight at his residence in Annūr.

Contents

As has alrady been stated, the GP, is a book of karaṇa type, and it is really a hand book. There are eight chapters named prakaraṇas in the book. Pañcāṅga, madhyama, sphuṭa, grahaṇa, miśra, pāta, mauḍhya, and chāyā are the eight prakaraṇas. The first chapter deals with the mode of calculation of pañcāṅgas. Hence, the author adopts certain aspects of the old parahita method, using the terminology of the new dṛk system.The main purpose of this chapter is to help the astrologer to calculate pañcāṅgas easily in their nityapañcāṅgapūjā which is a traditional custom of astrologers in Kerala. The star, day, tithi, karaṇa and yoga - these are the pañcāṅgas. The knowledge of these is essential for an astrologer for his daily work. So, the first chapter explains, how the pañcāṅgas are easily calculated. The second chapter mainly discusses the madhyamagaṇita. There are three main steps that the astronomers adopt to determine the real position of planets. They are madhyamagaṇita, ravimadhyadṛśya-sthānagaṇita and bhūmadhyadṛśyasthānagaṇita. Among them, the madhyamagaṇita is described here, and the others in the third chapter. The fourth chapter is grahaṇaprakaraṇa which deals with the calculation of eclipses of the Sun and the Moon. The fifth chapter explains how horoscopes are to be prepared. Here, we get the method of calculating lagnasphuṭa, gulikasphuṭa, nakṣatradaśā etc. In the sixth chapter, which is pātaprakraṇa, the author, deals with the lāṭa and vaidhṛta doṣas. Mauḍhyaprakaraṇa is the seventh. There, we have the method of

calculating mauḍhya of the planets. The last chapter is chāyāprakaraṇa, which explains the calculation of shadows.

Critical Analysis

GP follows the traditional customs of North Malabar. The acceptance of the transit day and the calculation of the Sun's longitude prove this. The book accepts Ujjayini as the centre of the earth and the dhruvakas, aphelions, perihilions etc, are calculated here as on that place. But the author gives guṇakāra and hāraka, calculated as on Payyannur. The book contains 366 verses in total. The author gives derivations of some technical terms, but most of them are accepted without showing derivations.

The first chapter deals with the mode of calculations of pañcāṅgas. The chapter focuses to calculate the true longitudes of the Sun and the Moon, the pañcāṅgas etc for the nityapañcāṅgapūjā. Because by calculating after this method, we get only a moderate result. It is enough for nityapañcāṅgapūjā, but for calculating horoscope etc, the correct and accurate results are needed. So, the author tries to get more corrections as karṣasamskāra, carasamskāra etc. in the second chapter itself. At the time of the publication of GP, different almanacs published from Kerala followed different methods. Most of them followed the parahita system but the calculation results by this method are found inaccurate today. To get an accurate result, more corrections are needed. So, the fundamentals and methods are to be changed. This is the main reason for the formation of the dṛk system. By this system, we get an accurate result. Hence, in the first chapter of GP the author retains the method of the parahita and promulgates the importance of the śuddha dṛk system by accepting the principal values or mūlyāṅkas of the new system. After the publication of GP most of the astrologers adopted the method given in it.

As said above nityapañcāṅgagaṇita is a traditional custom of Kerala astrologers. Gaṇapatipūjā, Sarasvatīpūjā, Kṛṣṇapūjā, Gurupūjā, and Sūryādipūjā are included in it. In the same order the author explains the invocatory verse. For the calculation of the stars, tithis etc; the true

longitudes of the Sun and Moon are needed. For this purpose, the author gives some tables as candravākyas, tithikendravākyas etc. as seen in the parahita system or vākyapaddhati method. The calculation using vākyas is the main characteristic of parahita system. For this reason, it was known as vākyapaddhati. But the fundamental values and measures given in the table are not the same as in the old. Here, the author follows dṛk system. Hence, this chapter shows, two-face characters, ie, the method of parahita and the values of dṛk system.

In the second chapter, the length of year, karaṇārambha, method of calculating madhymas, method of calculating Kali date, grahadhruvas, aphelion, perihilion, corrections of karṣa, cara, prāṇakalāntara, aharmāna, sūryakrānti etc. are explained. *GP* accepts the year of 365 days, 15 nāḍika and 23 vinādikās. It is adopted from the modern western astronomers like Simon Nukobe and Laveriyar. When we compare this to the figure given in the *Ketakīgrahagaṇita,* it is understood that the two figures of the length of year are equal.

The method of calculating Kali date is very easy for the astrologers. *GP* gives the minute calculation , that is, here we get the Kalidina saṅkhyā with gurvakṣara. Therefore, the method given in *GP* is very easy and useful for astrologers. The karaṇārambha, accepted in *GP* is 13.4.1899. If the astrologer calculates the longitudes of the planets according to the Kollam era, the acceptance of karaṇārambha as meṣa Ist will be very helpful, and if he calculates according to the Kali era, the day of completion of year is more helpful than other days as karaṇārambha. The karaṇārambha of the *GP* corresponds to Ist meṣa of 1113 and the day of completion of the Kali year 5000.

The author accepts the fundamentals of calculation on the basis of Ujjayini. Our ancestors accepted Ujjayini as the centre of the earth. The dhruvaka, aphelion dhruvaka, and perihilion dhruvaka are connected to Ujjayini. Two methods are given in *GP* to calculate the grahabhoga. One of them is guṇakārahāraka method. This is mostly used in the parahita system. It is said that, before the publication of *GP,* astrologers calculated their almanacs using parahita system.

Considering this in mind the author tries to add new principles with the old method. The average motions given in *GP* are very accurate. The author says that these are accepted from sophisticated methods. The *Ketakīgrahagaṇita, Gaṇitanirṇaya* and *Śuddhadṛggaṇita* also accept the same values of motions. In the correction of mean longitudes, the author accepts the correction of gravitation or karṣasamskāra. The Jupitor and the Saturn have a large mass, and so their attraction force is great. By this, the gravitation force (karṣabala) of these two are essential to correct the mean longitudes. In the case of other planets their karṣabala is too small to calculate. By the period of 918 years, the Jupiter and the Saturn complete one karṣavṛtta. Here, the author explains the method of calculating gravitation force of these two planets. Besides these the gravitation force of the Earth on the Moon is also remarkable. The orbit of the moon is changing, as the gravitation power of the Earth. Hence, there is a possibility of change of position of aphelion and node of the moon (tuṅga and rāhu). The correction of this is known as candrakarṣa. It is a good step taken by the author as it gives an accurate result. A collection of five corrections is named as aharmānasamskāra. Udayāntara, dēśāntara, cara, prāṇakalāntara and karṣaphala are the five corrections. In *GP* these five corrections are accepted to minute in the mean longitudes of planets. For calculating the corrections, the knowledge of the trigonometry is essential. So, the author explains the different aspects of trigonometry. The second chapter is the base for calculating true longitudes of planets, and so it is very important.

The most important part in the astrological calculation is the calculation of true longitudes. The two chapters - madhyamaprkaraṇa and sphuṭaprakaraṇa - explain the process of grahasphuṭagaṇita. The result by using *GP* method is very accurate. The most easy calculation among the grahasphuṭagaṇita is the sūryasphuṭagaṇita. Only two steps are adopted there - determination of the mean longitude and the correction in it by mandaphala.The author explains the method of calculating mandaphala. For the easy calculation of mandaphala correction, the author gives the tables of mandaphala and mandakendra.

This is very useful and helpful for an astrologer. The tables given in *GP* are proved very accurate. It is prepared for the twenty four chords. The method of calculating mandaphala described in *GP* is very simple. The author follows two methods to decide the mandaphala in a shortest way, and to correct it as minute as it can. If you need mandaphala in an average, you can accept the first method; if you want its minute form the second method can be accepted.The mandaphala given to the Mars, Mercury, Venus and Saturn are also found very accurate and correct. The most difficult part in the grahasphuṭagaṇita is the calculation of the candrasphuṭa. The moon takes a short period for its revolution and so its movement comes very fast than those of other planets. The moon revolves round the Sun and the earth. Hence, the calculation of true longitude of the Moon is a complecated process. To get the minute and accurate candrasphuṭa, a minimum of twenty three corrections are needed. *GP* explains five corrections as aharmāna and seven kendrasamskāra. But in *Śuddhadṛggaṇita,* the author explains 23 corrections and so the results according to *GP* and the *Śuddhadṛggaṇita* show some difference.

The correction of śīghraphala is another important topic explained in this chapter. There are two steps for the calculation of śīghraphala. At the first step, we get an average śīghraphala. The second step explains the method of caluculating minute śīghraphala. The formula given for the calculation of śīghraphala of Mercury and Venus is different from that of Mars, Jupiter and Saturn. For the calculation of śīghraphala of Mercury and Venus, it is explained as,

$$\frac{\text{Grahamadhyamamandakarṇam x bhujajyā}}{\text{sūryasphuṭa mandakarṇam}}$$

and, for the calculation of the śīghraphala of Mars, Jupiter and Saturn, it is given as,

$$\frac{\text{Sūryasphuṭamandakarṇam X Jyā}}{\text{Sphuṭaśīghrakarṇam}}$$

After the calculation using these formulae, it is found that the

result of the śīghraphala of Mars, Jupiter and Saturn is same as the result in the table given in *GP,* but it is different according to Mercury and Venus. While comparing these with *GN* and *SD* we find that the results given in the table are the same and the results got by the calculation using the formula are different. If the formula for Mercury and Venus is changed as,

$$\frac{\text{Grahamadhyamamandakarṇabhujājyā}}{\text{Grahaśīghrakarṇa}}$$

then we will get the same result given in the table.

The most practical and easy method is given in *GP* for the calculation of the eclipses. The important thing here is the calculation of the longitudes to the darśānta. Among the seven kendrasamskāras of the Moon, the sixth, seventh and fifth are not necessary here. The author explains that the result of these three corrections and the result of the vikṣepavalana are the same. *GP* accepts vikṣepavalana as a separate correction and rejects the above three corrections in the calculation of lunar eclipse. *GN* and *SD* accept the kendrasamskāras and do not accept the vikṣepavalana. Firstly, the eclipses are determined by calculating grahasphuṭas. If there is any possibility for an eclipse, the astrologer proceeds to the next step. Spuṭaparvānta, discs of the planets, samparkārdha etc. are calculated. By these they can find out the accurate time of lunar eclipse. For the calculation of solar eclipse, lambanati, nata, muhūrtas, hārajyā, sphuṭalambana, sphuṭāntara, kendrāntara etc are needed. The calculation method given in *GP* is very simple and the result found very accurate. By comparing these with the calculations of other books like *SD* and *GN* no variation is found.

In the *Miśraprakaraṇa,* balapiṇḍagaṇita, daśāgaṇita, jātakagaṇita etc are explained. These topics are very useful for the prediction of future based on the horoscope. A detailed method is given in *GP* for the calculation of cakrārdha. Firstly determination of the cakrārdha is given. When the union of the sāyanasūrya and sāyanacandra occurs at

golārdha and golānta, the two types of cakrārdhas are happened. If it comes at golārdha, the cakrārdha named vaidhṛta happens, and if it comes at gōlānta the same named lāṭa happens. It is very useful for the adjustable thinking of the cakrārdhās. So an astrologer can omit these doṣas from the muhūrtas. Then the author explains, the method of calculating cakrārdha accurately. Krāntisāmya is the main process in the calculation of cakrārdha. The table of the krāntis is given in *GP*.

Three main topics, included in the next chapter are mauḍhya gaṇita, yutigaṇita and vakragaṇita. For the calculation of mauḍhya, yuti and vakra the author provides simple methods. Anticipating the mauḍhya, preparation of krānti and vikṣepa, corrections of grahasphuṭas, calculation of mauḍhya are the different steps. For this calculation, candraśarākarṣaṇaphala, krāntighātaphala, ārkṣaphala and grahacāraphala are needed. The author gives tables for the above. He does not explain the process of derivation of the same. When we compare the tables of *GP* with those of other similar books, we can see the accuracy and perfection of it. The yutigaṇita is explained in *GP* by five verses. Preparation of the discs of the planets and of sphuṭakṣepa are difficult to calculate. In *GP* it is not clearly explained. The processes of calculation for eclipses and yuti are almost the same.

In the last chapter the author gives the method of calculating shadows. In *GN* it is explained broadly, but in *GP* it is explained minutely. For the calculation of candracchāyā, the process is very complicated. More time and patience are required here.

We may conclude that *GP* tries to explain almost all the calculations in the jyotiṣagaṇita. We can understand that the author gives more importance to the calculation of grahasphuṭas and the eclipses. The results are very accurate, and so this book is accepted as the basic text for the modern jyotiṣa gaṇita. It is assumed that by its accuracy, the astrologers of Kerala accept the book as an authority for their daily calculations.



SECTION II
Āyurveda and Allied Sciences

Blindness - Its Cause and Cure According to Aṣṭāṅgahṛdaya

E.R. Ramabhai

Among the human organs, eye is very important and very delicate also. By nature, this is being protected. But inspite of that sometimes it is being afflicted by factors like heat and cold; vāta, pitta and kapha and these would finally lead to blindness or timira if neglected or not properly treated. This blindness is caused by the afflction of the optic nerves, ie. kāca or by the formation of a film or coating over the eyes, ie. paṭala. According to *Aṣṭāṅgahṛdaya*, there are four stages of blindness. According to the defect in the nerves, in the first stage, the person will have a blurred vision, ie. avyaktadṛṣṭi.

सिरानुसारिणि मले प्रथमं पटलं श्रिते।
अव्यक्तमीक्षते रूपं व्यक्तमप्यनिमित्ततः।।

In the second stage, the person could see with great strain; he could see the objects nearby but not the objects at a distance and minute objects (ie. short sight) ; sometimes the objects nearby would appear as though lying at a distance and vice versa:

प्राप्ते द्वितीयं पटलमभूतमपि पश्यति।
भूतं तु यत्नादासन्नं दूरे सूक्ष्मं च नेक्षते।।
दूरान्तिकस्थं रूपं च विपर्यासेन मन्यते।

Again, the objects would appear as circular. Sometimes, because of the doṣa (defect) in the centre of the eye, single object

would appear as double; if the defect is manifold single object would appear as manifold; if the defect is internal short object would appear as big and vice versa; if the defect is at the lower portion, then the person could not see the objects nearby; if it is in the upper portion, the person could not see the objects at a distance; if the defect lies on one side of the eye, he could not see the objects at the sides. All these defects go by the name timira.

दोषे मण्डलसंस्थाने मण्डलानीव पश्यति।
द्विधैकं दृष्टिमध्यस्थे बहुधा बहुधास्थिते।।
दृष्टेरभ्यन्तरगते ह्रस्ववृद्धविपर्ययम्।
नान्तिकस्थमधःसंस्थे दूरगं नोपरिस्थिते।
पार्श्वे पश्येन्न पार्श्वस्थे तिमिराख्योऽयमामयः।।

In the third stage the eye gets kācatva. In this stage if neglected, the eye will slowly lose its power of vision:

प्राप्नोति काचतां दोषे तृतीयपटलाश्रिते।
तेनोर्ध्वमीक्षते नाधस्तनुचैलावृतोपमम्।।

By this kācatva, a person could see only upwards and not downward objects. This is just like the vision being obstructed by thin cloth. When colour changes power of vision also is lost gradually. When eye is neglected in this stage, it will lead to the fourth stage and the vision should be completely obstructed.

तथाप्युपेक्षमाणस्य चतुर्थं पटलं गतः।
लिङ्गनाशं ततः कुर्वन् छादयेद् दृष्टिमण्डलम्।।

The above mentioned are the general defects of the vision. But specifically, blindness would occur because of vāta, pitta or kapha, the three humours.

तत्र वातेन तिमिरे व्याविद्धमिव पश्यति।।
चलानिलारुणाभासं प्रसन्नं चेक्षते मुहुः।
जालानि केशान् मशकान् रश्मींश्चोपेक्षितेऽत्र च।।

काचीभूते दृगरुणा पश्यत्यास्यमनासिकम्।
चन्द्रदीपाद्यनेकत्वं वक्रमृज्वपि मन्यते।।
वृद्धः काचो दृशं कुर्याद्रजोधूमावृतामिव।
स्पष्टारुणाभां विस्तीर्णां सूक्ष्मां वा हतदर्शनाम्।।

In the first case, the curved objects would appear as straight. When the eye gets affected by vāta, the vision will be obscured, unsteady, of red-hue, seems to be clear, feels the face as without nose, feels the moon, light etc, as manifold, if the kāca is grown much, the vision will become blurred as though covered with smoke or dust. When afflicted by vāta, the eye nerves would get contracted and give rise to the defect called gambhīrā.

When timira is caused by pitta (bile), the eye could see the objects illuminated by lightning, objects resembling the wings of peacock and tittiri birds; generally the dark objects and the pariveṣa (halo) of sun and moon.

पित्तजे तिमिरे विद्युत्खद्योतद्योतदीपितम्।
शिखितित्तिरिपत्राभं प्रायो नीलं च पश्यति।।
काचे दृक् काचनीलाभा तादृगेव च पश्यति।
अर्केन्दुपरिवेषाग्निमरीचीन्द्रधनूंषि च ।।
भृङ्गनीला निरालोका दृक् स्निग्धा लिङ्गनाशतः।

In this case, the objects illumined by lightning etc., would be seen as the colour of the feathers of a peacock, and the eye will become dark like that of bee and loses its power of vision. Pitta will also give rise to short-sight and the eye will get yellow hue.

दृष्टिः पित्तेन ह्रस्वाख्या सा ह्रस्वा ह्रस्वदर्शिनी।।
भवेत्पित्तविदग्धाख्या पीता पीताभदर्शना।

When the eye gets affected by kapha (phlegm), it could see the glossy and white objects.

कफेन तिमिरे प्रायः स्निग्धं श्वेतं च पश्यति।।

In such cases, the eye will shrink in the light and expand in the shade. The eye would become white like conch, moon etc. The bindu will be moving like a water drop on lotus-leaf.

When the vision gets affected by blood, the eye could see only red or black objects. When the blindness is total, the eye would not be bright and could not see anything.

रक्तेन तिमिरे रक्तं तमोभूतं च पश्यति।।
काचेन रक्ता कृष्णा वा दृष्टिस्तादृक् च पश्यति।
लिङ्गनाशेऽपि तादृग् दृङ् निष्प्रभा हतदर्शना।।

When the eye gets affected by the disease called nakulāndha, it could recognise the objects only during day and not at night.

नकुलान्धः स तत्राह्नि चित्रं पश्यति नो निशि।

There is another defect called दोषान्ध when the vision will get blurred when the sun sets. When afflicted by heat and suddenly immersed in cold water, the eye would be affected in three ways. This is known as amlavidagdhā. When the person is afflicted by agony, fever, head (brain) disease, eye being also afflicted by vāta, etc, the person would get an obscure vision of objects. This is called dhūmararoga.

शोकज्वरशिरोरोगसन्तप्तस्यानिलादयः।।
धूमाविलां धूमदृशं दृशं कुर्युः स धूमरः।

Totally 27 types of blindness have been described in *Aṣṭāṅgahṛdaya.*

After enumerating different reasons for timira, the author prescribes many eatable drugs and ointments for external application, to cure the above mentioned eye-diseases. A few such recipes are described here.

Many ghṛtas and kaṣāyas are prescribed to cure timira caused by many reasons. Then he prescribes añjanas or medicinal pastes made of different ingredients for external application. The author then describes the method of removing the cataract. Finally he gives

instructions to diagnose the defects and how to protect the eyes generally.

The author says that these are mentioned by Ātreya and others:

अथातस्तिमिरप्रतिषेधं व्याख्यास्यामः
इति ह स्माहुरात्रेयादयो महर्षयः।

Let us see a few such ghṛtas.

(1) त्रिफलाघृतम्

Eight palas of त्रिफला should be boiled in one āḍhaka of water till it is reduced to 1/4 of the quantity. This should be mixed with equal amount of milk and boiled till it gets its required form (अर्धप्रस्थ) and again should be mixed with sugar or honey (mākṣika) and should be drunk by the person whose eyes are afflicted.

त्रिफलाष्टपलं क्वाथं पादशेषं जलाढके।।
तेन तुल्यपयस्केन त्रिफलाफलकल्कवान्।
अर्धप्रस्थो घृतात्सिद्धः सितया माक्षिकेण वा।।
युक्तं पिबेत्ततिमिरी तद्युक्तं वा वराददाम्।

The triphalākvātha along with ghee (sarpiḥ) would cure timiraroga. The food mixed with triphalā powder also acts in the same way.

(2) Rice mixed (cooked) with cold milk, along with triphalā or (along with) honey or sugar can be eaten in the morning. This could be eaten either with harītakī, or mṛdvīkā, śarkarā or kṣaudra separately. Thus when taken constantly would control timira.

पायसं वा वरायुक्तं शीतं समधुशर्करम्।
प्रातर्भक्तस्य वा पूर्वमद्यात्पथ्यां पृथक् पृथक्।।
मृद्वीकाशर्कराक्षौद्रैः सततं तिमिरातुरः।

Like this pratotādighṛta, mahātraiphalāghṛta, etc., are described by the author. Next many añjanas are described.

त्रिंशद्भागा भुजङ्गस्य गन्धपाषाणपञ्चकम्।।

शुल्बतालकयोर्द्वौ द्वौ वङ्गस्यैकोऽञ्जनात्रयम्।
अन्धमूषीकृतं ध्मातं पक्वं विमलमञ्जनम्।।
तिमिरान्तकरं लोके द्वितीय इव भास्करः। (31b - 33a)

30 parts of sīsaka (lead), 5 parts of gandhapāṣāṇa (sulphur), 2 parts each of śulba (copper) and tālaka (palmyra), one part of vaṅga (trapu - tin) and three types of añjana (kṛṣṇāñjana, puṣpāñjana and rasāñjana) everything put in the andhamūṣa, should be heated and treated; but should not be oxidised.

भुजङ्गादीनां शोधितानामत्र प्रयोगः न तु मारितानाम्

When this is applied to the eye afflicted by timira, it would remove the timira like sun removing darkness. The tuttha (copper sulphate) when heated many times in gomūtra, chāgalarasa, amlakanjiha, strīstanya, havis, viṣa and mākṣika would strengthen the vision when applied. The author described that a śalākā (thin rod or needle) of sīsa when heated again and again in the triphalākaṣāya, bhṛṅgarasa, saviṣajya, ajāpayaḥ and yaṣṭirasa (seven times boiled) and applied to the eye with or without añjana would cure the timira. This is called dṛṣṭaśalākā.

Another one:

रसेन्द्रभुजगौ तुल्यौ तयोस्तुल्यमथाञ्जनम्।
ईषत्कर्पूरसंयुक्तमञ्जनं तिमिरापहम्।।

When mercury and lead of equal quantity mixed with añjana (sulphide of lead) of the quantity of the mixture and a little quantity of camphor are treated chemically, that paste when applied would remove blindness. An interesting recipe to cure timira we find in the following verse:

कृष्णसर्पं मृतं न्यस्य चतुरश्चापि वृश्चिकान्।
क्षीरकुम्भे त्रिसप्ताहं क्लेदयित्वा प्रमन्थयेत्।।
तत्र यन्नवनीतं स्यात्पुष्णीयात्तेन कुक्कुटम्।
अन्धस्तस्य पुरीषेण प्रेक्षते ध्रुवमञ्जनात्।।

When dead (black) cobra, along with four scorpions, put inside a pot of milk and allowed to decay for three weeks and then churned, the butter would be removed out of it and it should be administered as food to a cock. The puriṣa of that cock will be capable of curing timira and the person would get back his vision.

Again we find:

कृष्णसर्पवसा शङ्खः कतकात्फलमञ्जनम्।
रसक्रियेयमचिरादन्धानां दर्शनप्रदा।।

The blindness will be removed (cured) if the chemical combination of the fat of a black-cobra, conch, clearing nut and añjana is applied to the eyes.

रत्नानि रूप्यं स्फटिकं सुवर्णं
स्रोतोऽञ्जनं ताम्रमयः सशङ्खम्।
कुचन्दनं लोहितगैरिकं च
चूर्णाञ्जनं सर्वदृगामयघ्नम्।।

If the paste (añjana) formed out of precious stones (gems) silver, crystal, gold, sroto' ñjana, copper, conch, raktacandana and kumkum (or china clay) is applied to the eyes, will cure any disease pertaining to eyes.

At the end of the chapter, the author quotes the instructions of sage Nimi, to protect the vision thus:

अहितादशनात्सदा निवृत्ति-
र्भृशभास्वच्चलसूक्ष्मवीक्षणाच्च।
मुनिना निमिनोपदिष्टमेतत्
परमं रक्षणमीक्षणस्य पुंसाम्।।

After prescribing the recipes in general manner, medicines for eye diseases, specifically caused by vāta, pitta and kapha are prescribed.

For the timira afflicted by vāta, the ghṛta mixed with daśamūlakvātha, along with four times quantity of milk, treated with triphalākalka should be taken by the patients. Then he should take

milk which is treated with triphalā and pañcamūla (kvātha) along with eraṇḍataila (caster oil).

वातजे तिमिरे तत्र दशमूलाम्भसा घृतम्।
क्षीरे,चतुर्गुणे श्रेष्ठाकल्फपक्वं पिबेत्ततः।।
त्रिफलापञ्चमूलानां कषायं क्षीरसंयुतम्।
एरण्डतैलसंसुक्तं योजयेच्च विरेचनम्।।

When the eye gets afflicted by pitta (bile), the ghṛta treated with jīvanī (ह. जीवन्ती), and phalatrika (triphalā) should be taken.

पित्तजे तिमिरे सर्पिजीवनीयफलत्रयैः
विपाचितं पाययित्वा स्निग्धस्य व्यधयेत्सिराम्।।
स्निग्धस्य सतः सिरां व्यधयेत्।
शर्करैलात्रिवृच्चूर्णैर्मधूयुक्तैर्विरेचयेत्।

The añjana prepared with sauvīrāñjana, tutthaka, śṛṅgī, dhātrīphala, sphaṭika-karpūra of the proportion of five parts, five parts (śṛṅgyāmalaka), three parts each, sphaṭika karpūra one part, when all these are treated chemically, the anjaña formed would cure timira.

सौवीराञ्जनतुत्थकश्रृङ्गीधात्रीफलस्फटिककर्पूरम्।
पञ्चांशं पञ्चांशं त्र्यंशमथैकांशमञ्जनं तिमिरघ्नम्।।

XIII.36b-37a.

When the timira is caused by śleṣma, is cured by the ghṛta formed of amṛtā, kvātha, varā, kaṇa, and śṛta.

श्लेष्मोद्भवेऽमृताक्वाथवराकणश्रृतं घृतम्।
विध्येत्सिरां पीतवतो दद्याच्चानु विरेचनम्।।
क्वाथं पूगाभयाशुण्ठीकृष्णाकुम्भनिकुम्भजम्।

The timira caused by rakta would be cured thus:

द्राक्षया नलदरोध्रयष्टिभिः शङ्खताम्रहिमपद्मपद्मकैः।
सोत्पलैश्छगलदुग्धवर्तितैरस्रजं तिमिरमाशु नश्यति।।

Again the treatment for timira caused by pitta has been

described. Similarly medicines and añjanas are prescribed for nakulāndha, rātryandha etc.

For niśāndha, the añjana prepared out of ghṛta, kṣudra, gomaya, svarasa, tārkṣya, gairika and tālīśa, should be applied.

रसक्रिया घृतक्षौद्रगोमयस्वरसद्रुतैः।
तार्क्ष्यगैरिकतालीसैर्निशान्धे हितमञ्जनम्।। (XIII. 84)

For rātryandha or niśāndha, the tender shoots of jīvantī treated with ghee, should be taken in. Similarly atimuktaka, eraṇḍa, śephālī (nirguṇḍī) and abhīru (śatāvarī) treated with ghee should be taken in.

घृते सिद्धानि जीवन्त्याः पल्लवानि च भक्षयेत्।
तथातिमुक्तकैरण्डशेफाल्यभीरुजानि च।।
भृष्टं घृतं कुम्भयोनेः पत्रैः पाने च पूजितम्।

In the 14th chapter, the author described the timira caused by kapha (phlegm) and the consequences and the remedy or cure for the same.

अथातो लिङ्गनाशप्रतिषेधं व्याख्यास्यामः।
विध्येत्सुजातं निःप्रेक्ष्यं लिङ्गनाशं कफोद्भवम्।
आवर्तक्यादिभिः षड्भिर्विवर्जितमुपद्रवैः।।

Here the obstruction caused to vision is, when the eye is being afflicted by phlegm (kapha) when the timira has been fully ripe. How to cure it? And how to remove the six types of distress? (Here it seems that the author is referring to cataract).

When the kaphodbhavaliṅganāśa has not become ripe, uneven, resembling the dadhimastu (colour of the cream of curd), when removed by a thin needle would grow again; would cause severe pain, sight would be blurred (and the person would stumble) would be augmented by the food of kapha predominate or otherwise.

सोऽसञ्जातो हि विषमो दधिमस्तुनिभस्तनुः।
शलाकयाऽवकृष्टोऽपि पुनरुर्ध्वं प्रपद्यते।।

करोति वेदनां तीव्रां दृष्टिं च स्थगयेत्पुनः।
श्लेष्मलैः पूर्यते चाशु सोऽन्यैः सोपद्रवश्चिरात्।।

The (liṅganāśa) cataract would be white since śleṣma is white but if affected by other defects such as vāta then it would be nīla (black or blue).

श्लैष्मिको लिङ्गनाशो हि सितत्वाच्छ्लेष्मणः सितः।
तस्यान्यदोषाभिभवाद् भवत्यानीलता गदः।।
तत्रावर्तचला दृष्टिरावर्तक्यरुणाऽसिता।
आवर्तक्यादियिः षड्भिः- आवर्तकी-शर्करा-राजीमती-छिन्नांशुका-
चन्द्रकी-छत्रकीभिः।

Among the six doṣas- in āvartakī, the vision will not be steady reddish and black (the six types of distress one, āvartakī, śarkara, rājīmatī, chinnāmśuka, candrakī and chatrakī).

In all these thus the colour of the eye is being described. For example in chatrakī, the vision will not be of one colour, it would be nīlavarṇa (i.e. black)

छत्राभा नैकवर्णा च छत्रकी नाम नीलिका।

The method of removing the cataract has been explained by the author thus:

अथ साधारणे काले शुद्धसम्भोजितात्मनः।
देशे प्रकाशे पूर्वाह्ने भिषग्जानूच्चपीठगः।।
यन्त्रितस्योपविष्टस्य स्विन्नाक्षस्य मुखानिलैः।
अङ्गुष्ठमृदिते नेत्रे दृष्टौ दृष्ट्योत्प्लुतं मलम्।।
स्वां नासां प्रेक्षमाणस्य निष्कम्पं मूर्ध्नि धारिते।
कृष्णादर्धाङ्गुलं मुक्त्वा तथार्धार्धमपाङ्गतः।।
तर्जनीमध्यमाङ्गुष्ठैः शलाकां निश्चलं धृताम्।
दैवच्छिद्रं नयेत्पार्श्वादूर्ध्वमामन्थयन्निव।।
सव्यं दक्षिणहस्तेन नेत्रं सव्येन चेतरत्।
विध्येत्।।

After the kapha is being removed, the eye should not see very minute object, very bright object etc suddenly.

यन्त्रणामनुरुध्येत दृष्टेरास्थैर्यलाभतः।
रूपाणि सूक्ष्मदीप्तानि सहसा नावलोकयेत्।।
शोफरागरुजादीनामाधिमन्यस्य चोद्भवः।
अहितैर्वेधदोषाच्च यथास्वं तानुपाचरेत्।।

In order to pacify the eyes, the ghṛta mixed with the kalka (residual) of dūrvā, yava, gairika and sārivā should be applied on the face (i.e. the face should be anointed with ghṛta).

कल्किताः सघृता दूर्वायवगौरिकसारिवाः।
मुखालेपे प्रयोक्तव्या रुजारागोपशान्तये।।

Thus so many methods are described to pacify the eyes.

In the next chapter the author described the methods to find out the different types of timira.

In the 16th chapter, the author gives many methods and recipes to prevent eye diseases (timira).

The horse-gram should be mixed with gośakṛdrasa and tied in a cloth. Should be dried then. This would pacify the timira caused by vāta.

आरुण्याच्छगणरसे पटावबद्धाः सुस्विन्ना नखवितुषीकृताः कुलत्थाः।
तच्चूर्णं सकृदवचूर्णनान्निशीथे नेत्राणां विधमति सद्य एव कोपम्।।

For example, the pain in the eyes caused by vāta, pitta, kapha and sannipāta would be removed quickly, if the juice of tender shoots of śigru (a pot herb) and mākṣika is applied.

वातपित्तकफसन्निपातजां नेत्रयोर्बहुविधामपि व्यथाम्।
शीघ्रमेव जयति प्रयोजितः शिग्रुपल्लवरसः समाक्षिकः।।

Similarly śvetarodhra with madhu and ghṛta, when being powdered, when put it in a vastra and softened by stanya, when applied (or presented with it) would cure the timira caused by pitta and rakta.

श्वेतरोध्रं समधुकं घृतभृष्टं सुचूर्णितम्।

वस्त्रस्थं स्तन्यमृदितं पित्तरक्ताभिघातजित्।।

The eighteen varieties of eye-diseases which are distressing the eyes for a long time, and collectively called as pilla have been mentioned, and the method of curing them also are described.

उत्क्लिष्टाः कफपित्तास्रनिचयोत्थाः कुकूणकः।

पक्ष्मोपरोधः शुष्काक्षिपाकः पूयालसो बिसः।।

पोथक्यम्लोषिताऽल्पाख्यः स्यन्दमन्था विनाऽनिलात्।

एतेऽष्टादश पिल्लाख्या दीर्घकालानुबन्धिनः।

First the method of general treatment has been described. One or two methods are given here. The seeds of karañja, surasa, sumana, koraka (Indian beech, tulasi, jātipuṣpa, mukula) everything being crushed are boiled in water. When boiled chemical reactions would take place. The añjana made out of it would cure pilla (doṣa) and the eye lashes also would grow.

करञ्जबीजं सुरसं सुमनः कोरकाणि च।।

संक्षुद्य साधयेत् क्वाथे पूते तत्र रसक्रिया।

अञ्जनं पिल्लभैषज्यं पक्ष्मणां च प्ररोहणम्।।

Mixture of haritāla (yellow sulphur), sauvīra (badari) añjana and twice the amount of the above mixture of tāmracūrṇa - these two should be made nice powder. When this powder is applied with a śalākā to the eyes, would cure the pilla (doṣa) and the eye-lashes will grow even applied once.

अलं च सौवीरकमञ्जनं च ताभ्यां समं ताम्ररजः सुसूक्ष्मम्।

पिल्लेषु रोमाणि निषेवितोऽसौ चुर्णः करोत्येकशलाकयापि।।

After describing many recipes, the author finally gives an instruction, generally to all who are desirous of possessing good eyes. Everybody should consume (necessary quantity) of old yava (barley), wheat, rice, green-gram which is capable of removing kapha and pitta. Vegetables etc. should protect the eyes from schorching heat, protect

the foot, periodical check up of the eyes. One should avoid the food which would cause indigestion. Avoid anger and agony (too much). Avoid sleep at day-time and waking at night. In this way even with regulated food, one can protect the eyes. Again he explains that in the middle of the feet, two sirās (veins) in each foot, in a slight form, are reaching the eyes. If these veins are afflicted, that would afflict the eyes. Hence everyone should protect their veins which in turn would protect the eyes.

सर्वदा च निषेवेत स्वस्थोऽपि नयनप्रियः।।

पुराणयवगोधूमशालिषष्टिककोद्रवान्।

मुद्गादीन् कफपित्तघ्नान् भूरिसर्पिःपरिप्लुतान्।।

शाकं चैवंविधं मांसं जाङ्गलं दाडिमं सिताम्।

सैन्धवं त्रिफलां द्राक्षां वारि पाने च नाभसम्।।

आतपत्रं पदत्राणं विधिवद्दोषशोधनम्।

वर्जयेद्वेगसंरोधमजीर्णाध्यशनानि च।।

क्रोधशोकदिवास्वप्नरात्रिजागरणातपान्।

द्वे पादमध्ये पृथुसन्निवेशे शिरे गते ते बहुधा च नेत्रे।

ता म्रक्षणोद्वर्तनलेपनादीन् पादप्रयुक्तान्नयने नयन्ति।।

मलौष्ण्यसङ्घट्टनपीडनाद्यै-

स्ता दूषयन्ते नयनानि दुष्टाः।

भजेत्सदा दृष्टिहितानि तस्मा-

दुपानदभ्यञ्जनधावनानि।।



Carakasamhitā

A.P. Haridasan

Āyurveda is considered as upaveda. It simply means that the science of life is an importatnt branch of knowledge. It is a stream of knowledge coming down from generation to generation. Man has always worried on his ill health from the time immemorial and tried and succeeded to find out remedies for most of the ailments. As the knowlege developed, Āyurveda was divided into 8 specialities - kāyacikitsā (internal medicine), śalya (surgery), śālākya (diseases of head), kaumārabhṛtya (paediatrics), agadatantra (toxicology), bhūtavidyā (pertaining to microorganisms or spirits), rasāyana (promotive therapy) and vājīkaraṇa (pretaining to aphrodisiacs). Many treatises are composed on each branch developing to the rank of specialities, simultaneously permitting them to have interdisciplinary approach and two specialities developed rapidly - the School of Medicine and School of Surgery.

The School of Medicine was known as kāyacikitsā or Ātreaya punarvasusampradāya. The School of Surgery was famous as śalya or Dhanvanatarisamprādaya.

Authors / Evolution of Carakasamhitā

Ātreya Punarvasu had six important disciples. They were Agniveśa, Bhela, Jatukarṇa, Parāśara, Hārīta and Kṣārapāṇi. All of them composed their own books on the knowledge gained by them. Among them *Agniveśatantra* stood first and Ātreya was asked to modify the text

including other tantras. Later it was refined and enlarged by Caraka and hence the name *Carakasamhitā*. Further it was redacted by Dṛdhabala. So the present text of *Carakasamhitā* is the Agniveśatantra as refined by Caraka and redacted by Dṛdhabala.

Date of Carakasamhitā

As mentioned above, the text being written, modified and redacted by three authors. It naturally reflects that the date of the text is not a single one. On the basis of internal and external evidences the date of Agniveśa may be fixed as before Pāṇini (7th century B.C) and after the *Atharvaveda* (1500 B.C) ie. near about 1000 B.C. The period of Caraka may be fixed as near about 200 B.C. Dṛdhabala who has completed *Carakasamhitā* by adding 17 chapters in cikitsāsthāna and entire kalpasthāna and siddhisthāna may be said to have lived in 4th century A.D.

Planning of the text

The subject matter of the text is arranged in the following sections and chapters:

Section	No of chapters
1) Sūtrasthāna	30
2) Nidānasthāna	8
3) Vimānasthāna	8
4) Śārīrasthāna	8
5) Indriyasthāna	12
6) Cikitsāsthāna	30
7) Kalpasthāna	12
8) Siddhisthāna	12
Total	120 chapters

It is also believed that uttarasthāna was also there even at the time of *Agniveśatantra;* but it was not accepted in general.

Sūtrasthāna deals with the fundamentals of Āyurveda.

Chapters:

1 Dīrghamjīvitīya (on longevity)
2. Apāmārgataṇḍulīyam (seeds of apāmārga used for śodhana)
3. Āragvadhīyam (on āragvadha)
4. Ṣaḍvirecanaśatīyam (on 600 evacuations)
5. Mātrāśītīyam (quantity of diet etc)
6. Tasyāśītiyam (one's diet etc)
7. Navegāndhāraṇīyam (nonsuppression of urges)
8. Indriyopakramaṇīyam (introductory description of sense organs)
9. Khuddakacatuṣpadam (small quadruple)
10. Mahācatuṣpadam (great quadruple)
11. Tisraiṣaṇīyam (three desires)
12. Vātakalākalīyam (merits and demerits of vāta)
13. Snehādhyāya (unction)
14. Svedādhyāya (fomentation)
15. Upakalpanīya (equipments etc)
16. Cikitsāprabhṛtīyam (physician equipped for treatment)
17. Kiyantaśśirasīyam (no. of diseases in head etc)
18. Triśophīyam (three swellings etc)
19. Aṣṭodarīyam (8 abdominal diseases)
20. Mahārogādhyāya (major diseases)
21. Aṣṭauninditīyam (eight despicables)
22. Laṅghanabṛmhaṇīyam (reducing and promoting measures)
23. Santarpaṇīyam (over saturation)
24. Vidhiśoṇitīyam (properly formed blood)
25. Yajñapuruṣīyam (origin of person)
26. Ātreyabharadvājīyam (discussion among Ātreya and Bharadvāja)
27. Annapānavidhi (types of foods and drinks)

28. Vividhāśitapītīyam (various foods and drinks)
29. Daśaprāṇāyatanīyam (10 seats of vital health)
30. Daśamahāmūlīyam (10 great vessels of heart)

Nidānasthāna is the section on diagnosis.

Chapters: 1. Jvaranidānam (diagnosis of fever) 2. Raktapittam (internal haemorrhage) 3. Gulmam 4. Prameham (diabetes etc.) 5. Kuṣṭha (leprosy etc) 6. Śoṣa (tuberculosis etc) 7. Unmāda (mental disease) 8. Apasmāra (mental disease)

Vimānasthāna is the section on specific features:

Chapters: 1. Rasavimānam 2. Trividhakukṣīyam (three fold belly) 3. Janapadodhvamasanīyam (epidemics) 4. Trividharoga vijñānīyam (threefold sources of knowlede of disease characters) 5. Srotovimānam (channels) 6. Roganikam (groups of diseases) 7. Vyadhitarūpīyam (special features of appearance of diseases etc.) 8. Rogabhiṣagjitīyam (therapeutics of disease)

Śārīrasthāna is the section on the study of human body.

Chapters: 1. Kathitapuruṣīyam (types of personal self etc) 2. Atulyagotrīya (different clan) 3. Khuddakagarbhāvakrānti (minor chapter on descent of embryo) 4. Garbhāvakrānti (development of foetus etc) 5.Puruṣavicayam (knowledge about the person) 6. Śarīravicayam (knowledge on body) 7. Śarīrasaṅkhyā (enumeration of body parts) 8. Jātisūtrīya (principles of procreation)

Indriyasthāna is the section on signs of life and death.

Chapters:

1. Varṇasvarīyam (complexion and voice)
2. Puṣpitakam (flowered person)
3. Parimarśanīyam (palpable entities)
4. Indriyanikam (sense organs)
5. Pūrvarūpīyam (predormal signs)
6. Katamanisarīyam (physical abnormalities)

7. Pannarūpīyam (shadow and lustre)
8. Avākśīrasīyam (inverted image)
9. Syāvanimittīyam (blackish signs)
10. Sadyomaraṇīyam (signs of sudden death)
11. Anujyotīyam (poor digestion)
12. Gomayacūrṇīyam (cowdung-like powder)

Cikitsāsthāna is the section on therapeutics.

Chapters:

1. Rasāyana (promotive treatment)
2. Vājīkaraṇa (aphrodisiacs)
3. Jvara (fever)
4. Raktapitta
5. Gulma
6. Prameha
7. Kuṣṭha
8. Rājayakṣmā
9. Unmāda
10. Apasmara
11. Kṣatakṣīṇa (wounded & wasted)
12. Śvayathu (swelling)
13. Udara
14. Arśa (piles)
15. Grahaṇi (sprue)
16. Pāṇḍu (anaemia)
17. Hikkā (hiccup) and śvāsa (dyspnoea)
18. Kāsa (cough)
19. Atisāra (diarrhoea)
20. Chardi (vomiting)
21. Visarpa (eryspipeles)
22. Tṛṣṇā (polydipsis)
23. Viṣa (poisoning)
24. Madātyaya (alcoholism)
25. 2 types of vraṇa (wound)
26. Trimarmīya (3 vital organs)
27. Ūrusthambha
28. Vātavyādhi
29. Vātarakta
30. Yonivyāpat (disorders of female genitalia)

Kalpasthāna is the section on pharmaceuticals.

Chapters:

1. Madanakalpam (pharmaceutical preparation of madana)
2. Jīmūtakalpam
3. Ikṣvākukalpam
4. Dhamargavakalpam
5. Vatsakakalpam
6. Kṛtavedhanakalpam

7. Śyāmatrivṛtkalpam
8. Caturaṅgulakalpam
9. Tilvakakalpam
10. Sudhā (snuhī) kalpam
11. Saptalaśaṅkhinikalpam
12. Dantidravantī kalpam

Siddhisthāna deals with successful management.

Chapters:

1. Kalpanasiddhi (successful preparations)
2. Pañcakarmīyasiddhi (successful management of pañcakarma)
3. Vastisūtrīya (principles of enema)
4. Snehavyāpatsiddhi (successful management of unctuos enema)
5. Netravastivyāpatsiddhi (s.m. of complicatin of nozzle & enema pouch)
6. Vastivirecanavyāpatsiddhi (s.m. of complication of enema and purgation)
7. Vastivyāpatsiddhi (s.m.c. of enema)
8. Prasṛtayogīya (s.m. of prasṛta)
9. Trimarmīyasiddhi (s.m.c of 3 vital parts)
10. Vastisiddhi (s.m. of vasti)
11. Phalamātrāsiddhi (dose of enema prepared with fruits)
12. Uttaravastisiddhi

Importance of Carakasamhitā

It deals with the basic principles of Āyurveda.

It describes the macrouniverse and how it is connected with the microuniverse individual living being, let it be a human being or a microorgamism.

It finds the man as a wholesome individual.

It discusses variouos topics from genetics to our daily practices. It propagates holistic approach. It enables one to find out remedy for each and every problem arising at any time anywhere. It gives more than 2000 medicinal preparations. In the view of an expert in Sanskrit

literature, it may stand equal to any classic in Sanskrit. The most important thing which impresses us may be the method of describing a thing. It usually starts with a question. Then discussion commences. Various experts present their own views and try to establish their points. Serious discussion goes on. Finally the master concludes the discussion by finalising the point. *Carakasamhitā* is considered the oldest available authoritative text on medical science.

Commentators	**Commentary**	**Date**
1. Bhaṭṭāraharīścandra	Carakanyāsa	6th century
2. Svāmikumāra/Svaminātha	Carakapañjikā	7th century
3. Āṣāḍhavarma	Parihāravārtikam	8th century
4. Himadatta	____	8th century
5. Kṣīrasvāmidatta	Carakavārtikam	8th century
6. Patañjali	Carakavārtikam	8th century
7. Śivasaindhava	____	8th century
8. Vaiṣṇavācārya	____	8th century
9. Celladeva	____	8th century
10. Jejjaṭa	____	9th century
11. Sudhīrācārya	____	9th century
12. Mādhavācārya	____	9th century
13. Amitaprabha	Nyāsa	9th century
14. Bhadravarma	____	9th century
15. Bhasadattācārya	____	10th century
16. Brahmadeva	____	10th century
17. Bhīmadatta	____	10th century
18. Aṅgiri	____	10th century
19. Īśvarasena	____	10th century
20. Gayadāsa	Carakacandrikā	11th century
21. Naradatta	Bṛhattantrapradīpa	11th century
22. Cakrapāṇidatta	Āyurvedadīpikā	11th century
23. Vṛndakuntācārya	Vṛndaṭīkā or	11th century

	Vṛndaṭippaṇam	
24. Śrīkṛṣṇavaidya	Carakabhāṣyam	11th century
25. Bāṣpacandrācārya	____	12th century
26. Īśānadeva	____	12th century
27 Guṇakara	____	12th century
28. Jinadāsa	____	12th century
29. Maitreya	____	12th century
30. Nāgadeva	____	12th century
31. Bhavyadatta	____	12th century
32. Bahulakar	____	12th century
33. Sivadas Sen	Tattvapradīpikā	15th century
34. Gangadhara Roy	Jalpakalpataru	19th century
35. Yogindranath Sen	Carakopaskāra	20th century
36. Jyotiṣacandra Sarasvatī	Carakapradīpikā	20th century
37. Jaidev Vidyalankar	Hindi	20th century
38. Atridev Vidyalankar		20th century
39. Ramprasad Sharma		20th century
40. Vācaspati T.C.Parameswaran Moosad	Vācaspatyam (Malayalam)	20th century
41. M.Narayanan Vaidyar	Malayalam	20th century
42. Sree Gulab Kuverba Ayurvedic society Jamnagar	English	20th century
43. Dr. P.V. Sarma	English	20th century
44. Dr. Ramkaran Sarma and Vd. Bhagawan Das	English	20th century

Suśrutasamhitā

M.I. George

India has a rich medical legacy. Āyurveda has got its origin in ancient India. There are eight branches dealing with each speciality in Āyurveda. More or less they can be grouped under the broad terms, medicine and surgery. The excellence of surgical practice in Āyurveda is attributed much to Suśruta. This becomes evident as one goes through the celebrated compendium of surgery, *Suśrutasamhitā*. Today, when the high-tech Western medical proficiencies turn to grab a new holistic outfit, understanding and evaluating Suśruta's contrtibution in the practice of surgery and his imaginations about the surgical probabilities can stimulate even the 21st century surgeon. As Winston Churchill puts, 'the longer you can look back the further you can look forward.'

Suśruta - the author

Suśruta was the son of Viśvāmitra. The military teacher of Rāma and Lakṣmaṇa is different from Suśruta's father. Suśruta was said to have been sent to Divodāsa, the king of Vārāṇasi for tution and training in surgery. Divodāsa is also considered as Dhanvantarī incarnate. It is generally accepted that Dhanvantarī might have become symbol of surgical specialization, which was attained by Divodāsa by virtue of his extraordinary skill in surgery. Among the disciples of Kāśirāja Divodāsa Dhanvantarī, Aupadhenava, Vaitaraṇa, Aurabhra,

Pauṣkalāvata, Karuvīrya, Gopurarakṣita and Suśruta were prominent ones. The texts written by Aupadhenava, Aurabhra, Suśruta and Pauṣkalāvata are the original ones and became the sources of other surgical treatises. Out of these four texts, *Suśrutasamhitā* is the most popular one and is taught even these days. Most of the historians agree that Suśruta's period comes in between 600 B.C. and 300 B.C. The mythological basis of Lord Dhanvantarī being the originator of the surgical School and the historic basis of Divodāsa and Suśruta are complimentary in their total perspective.

Suśrutasamhitā

The most outstanding feature of *Suśrutasamhitā* is that it has stood over 2500 years with minimal additions and is being followed in medical practice even today. The description of the subject matter has been given in concise form to a major extent. Though it is essentially a text book of surgery, it covers all the aspects of medical practice under eight sub-specialities. The surgical concepts and procedures are discussed throughout.

Though surgery was practised as a distinct speciality other than the 'civil science' of medicine, it was not included in the encyclopedic tradition represented by *Carakasamhitā*. It is Suśruta, with a particular effort, a stroke of genius, to break down the barriers of traditional specialization and to merge both into the 'science of medicine.'

In *Suśrutasamhitā*, we find reflections of the personality of its author. His humane appraoch to the problem, his authority and grasp of the subject, his mastery over the art, his respect towards elders and his fellowmen, consideration towards assistants and students, and above all, the topmost concern to his patients are evident from his work.

Suśrutasamhitā is the first text to define health in terms of physical and mental serenity and well being which was incorporated by W.H.O recently. Suśruta was not only a practical surgeon but he was a good teacher also. He enjoined every young surgeon to undertake teaching programme lest one's knowledge becomes

stagnant. With the same motive, he translated his thoughts and experiences into a text book, *Suśrutasamhitā*. It consists of two broad sections. The first section named text related to surgery and is further divided into five cantos or sthānas. Sūtrasthāna is the first among them. It has got 46 chapters.The subjects dealt with under these chapters include: origin of medical science (Āyurveda), students' initiation ceremony, index of treaties, interpretations, pre-operative preparations and arrangements, seasonal regimen, description of blunt and sharp surgical instruments, the principles of experimental surgery, entry into the profession, preparations and uses of caustics, thermal cauterization, burns, the application of leeches, the description of blood, study on abnormality of humors, the techniques of plastic surgery, abscesses and their stages, wound care, diet and regimen for the wounded, classification of diseases, the eight surgical procedures, extraction of foreign bodies from the tissues, wounds of good or bad prognosis, dreams and omens, the untreatable diseases, fundamentals of the treatment of the patient, classification of drugs and their properties etc.

The second canto is nidānasthāna which illustrates the pathology and diagnosis of diseases, contains 16 chapters. Conditions like piles, urinary stones, fistula-in-ano, skin diseases including leprosy, urinary symptoms, abdominal enlargements, abnormal foetal presentations, spreading cellulites, sinuses and breast diseases, glandular swellings, cervical lymphadenopathy, goiters, scrofal swellings, venereal diseases, elephantiasis, fractures and dislocations are dealt with in this canto.

Śārīrasthāna, the third canto, mainly deals with the anatomical and obstetrical considerations. It has got 10 chapters discussing physical and metaphysical aspects of all living beings, normally of sperm and ovum, fertilization and development of fetus, fetal anatomy, anatomical considerations of vulnerable areas (marma). arteries and veins, puncturing of the veins for blood-letting and the anatomical considerations and care of the pregnant woman.

The fourth canto, cikitsāsthāna, contains 40 chapters. The first 23

chapters of this canto chiefly deal with the management of surgical diseases. Both medical treatment and surgical management of the same disease are described. The remaining chapters deal with the subjects like the prevention of diseases, the aphrodisiae treatment for the sexually weak, general restorative treatment, restorative treatment for promoting intellectual sharpness and longevity, prevention of natural diseases and distress by restorative treatment. It also explains procedures like oleation, sudation, emesis, purgation, enema, urethral and vaginal irrigation, fumigation, gargles, nasal administration etc.

The fifth canto named kalpasthāna has eight chapters. Toxicology is the topic discussed in this canto. Doctrines of the protection of foods and drinks from poisoning, inanimate and animate poisons, snake-bites, poisoning by rats, poisoning by insects and their treatment are explained here.

The second section of the book is called uttaratantra which contains 66 chapters. It is ascribed by some scholars to a later author of the same name. This part of the book deals with a variety of subjects including details of eye disease affecting each anatomical part of the eye and their management, treatment of eye injuries,. diseases of ear, nose and throat and their management, diseases affectiing head and their management, specific features of affliction of nine grahas and their management, gynaecological disorders and their treatment, the measures to keep health etc. Chapters 39 to 62 of uttaratantra deal with general medicine and psychiatry in Āyurveda. The management of the seizures caused by super human agencies, the management of diseases due to the suppression of natural urges are also included in this section. Chapter 65 is termed as 'tantrayukti', which explains 32 keys to be used by the reader while using the text.

While going through the text, one can easily find that surgery was practised by eminent persons in India with a reasonable degree of success. It is interesting to note that the theories of surgery propounded by Suśruta hold good even today. For example : for centuries till Lister's period (1827-1912) surgeons of the

West welcomed the formation of 'laudable pus' in the wound and actually employed several measures to produce it. Suśruta, contrary to this, observed that clean wounds without the formation of pus heal faster. This upholds the present concept of primary healing. Surgical ethics and code of conduct of an ideal surgeon have been briefed in *Suśrutasamhitā*. Suśruta was the first surgeon to classify surgical instruments adopting nomenclature. Both blunt and sharp instruments were grouped in distinct categoires, grouping which is complete in every respect even now.

Suśrutasamhitā promotes interdisciplinary approach in studies. It is likely during the course of training that many allied branches of this science might have received references. To understand those subjects better, one has to study them under specialists, because knowledge of one science alone is insufficient to have command over it unless it is supported by an insight into as many allied disciplines as necessary. Therefore, Suśruta advises, to be seekers of knowledge by studious habits, discussions and acquintance with other works on similar subjects. Plastic surgery is the unique contribution of Suśruta for which the world is indebted to him.

Suśruta has elabortaed and advanced the basic concepts of the properties and action of drugs. *Suśrutasamhitā* introduces many specific drugs for treatment. He classified drugs in 37 groups according to therapeutic uses.

Commentaries

There are about 20 important commentaries on *Suśrutasamhitā*. Dalhaṇa's commentary and Gayadāsa's commentary are the most important and sceholiastic works. Dalhaṇa lived during the second half of 12th century A.D. He was a versatile scholar and a well-read commentator. This is evident from the long list of authors and works quoted by him in the commentary on *Suśrutasamhitā*. 45 Samhitās and 21 other commentaries have been quoted by Dalhaṇa. From Dalhaṇa's commentary one can perceive that there were different versions of the text *Suśrutasamhitā* prevalent in different traditions.

Commentators belonging to various traditions have held up their traditional version and have presented their views on that basis. While presenting his interpretations, Dalhaṇa analyses these versions critically and many a time gives his own version. Dalhaṇa had particular leaning towards Gayadāsa regarding textual versions. Gayadāsa lived during 11th century A.D. and was the physician of King Mahīpāla of Bengal. Jejjaṭa, Śrīmādhava, Bhāskara, Cakrapāṇidatta, Haraṇacandra, and Bhāskara Govinda Ghanekar, have also written commentaries on *Suśrutasamhitā*. Commentaries written by Gayadāsa and Dalhaṇa are the popular ones and the learners of Āyurveda chiefly depend upon these commentaries for clearing their doubts. Cakrapāṇidatta, who wrote the most popular commentary on *Carakasamhitā*, has written commentary on *Suśrutasamhitā* also. But it is published only in part.

Suśrutasamhitā has also been translated into many foreign languages. During the 8th century A.D. an Arabic version called Kitabi - i- sustud, was composed by Ilon Abillsaitial . In 1883 U.C. Dutt has translated *Suśrutasamhitā* into English. Another English translation by K.L. Bhishagratna was published in 1907. Hessler rendered *Suśrutasamhitā* in Latin and Vellus in German. English translation named *Ancient Indian Surgery* edited by G.D.Singal in 10 volumes is an authentic work.

Suśruta stands out as a surgical Colossus, his glory not being dimmed by the mist of 2500 years. We can imagine his hermetic figure on the snanghats of the holy city of Vārāṇasi in the early hours in the loneliness of meditation. Long before the sun rises, he would be seen in his ashram giving a discourse to his disciples or attending the sick.

Suśruta's practice was not a profession, but rather a prayer and a way of life. He was the greatest surgeon of the pre-medieval period and that his contributions have enriched the evolution of the current practice of surgery. I am sure, it is found to continue as an endless tradition.



Contribution of Vaidyaratnam P. S. Warrier to Āyurveda

Thanu.V. G

Panniyampally Sankara Warrier was born on 16th March 1869 as the only son of Rama Warrier of Marayamangalam Mankulangara Variyam and Kunjikutty Varasyar of Panniyampally Variyam.[1] Sankaran, his grandfather, was a great Āyurveda physician of that time. The very name was given to the grandson.

Education

P.S. Warrier started his education at the age of four under his uncle Kuttikrishna Warrier and learned Sanskrit under various eminent scholars.[2] He studied preliminary lessons in Āyurveda from Konoth Achuthan who was a palace physician. Then in the year 1885, he approached Kuttanchery Vasudevan Mooss, one of the famous Aṣṭavaidyas of that time and studied Āyurveda under him in the Gurukula system. Then he started practicing at Kottakkal.

As a result of rigorous practices during Gurukula education, he had a serious eye trouble and so consulted Dr.V. Varghese, a surgeon at the Government Hospital. There he had to undergo a minor surgery for his eye. After the treatment, Dr. Varghese recommended to him that the learning of the principles of Allopathic system would help him in his carrier as a physician. Hence P.S. Warrier learned the principles of Allopathic system, modern anatomy and physiology for

about 3 years under Dr. Varghese. P.S. utilised this new knowledge for promoting the Āyurvedic system.

His knowledge of medicine thus embraced both indigenous and Western. Though he learned Āyurveda he respected Western medical knowledge especially surgery, anatomy and physiology, which considerably influenced his vision of reform.

Vision

P.S. Warrier had a liberal and catholic outlook. Although deeply religious and orthodox in beliefs and practices his attitude towards other faiths was influenced by cosmopolitan principles.

As observed by Dr. K.N. Panicker , P.S. Warrier was free from many of the prejudices of his time. Warrier had an open critical and eclectic mind.[3] He was imaginative but practical, enthusiastic but patient and energetic but systematic. This aspect helped him in bringing out his reformal attitude in success.

Once he wrote in *Dhanvanthari:* "The antiquity of Āyurveda is a matter of pride for all of us, but nobody can deny that its present state is quite deplorable. Due to reasons, both internal and external, our medicinal system has steadily declined while in contrast, other systems have progressed in an equal degree. The people of West examine the laws of nature and invent new dimensions of science, thereby repeatedly revising the earlier scientific knowledge. We, on the other hand, blindly believe that old sciences are perfect. As a reslut, we have not only failed to progress but have also been pushed down the ladder by others. If this state of affairs continues there is no doubt that Āyurveda will become totally extinct".[4] Here he hints the need of reforms in Āyurveda. The internal causes were related to three factors 1. stagnation of knowledge, 2. ignorance of the practitioners and 3. nonavailability of quality medicine.

Contemporary practitioners did not imbibe this knowledge sufficiently. The classical texts were either not easily available or if available, most of the practitioners did not have the necessary language

equipments to assimilate their contents. More easily accessible texts and commentaries in vernacular languages were also not adequately made use of. Instead of mastering the fundamental principles of the text most of the practitioners adopted the easier method of oral instruction durionq short spells of apprenticeship under senior physicians.

As a result, by the end of the nineteenth century an overwhelming majority of indigenous practitioners were ignorant of their art purveying borrowed prescriptions. Their only aim and objective was pursuit of their livelihood.[5]

Another major weakness of the indigenous system was the method adopted for preparing medicines. Medicines in prepared forms were very few and hence the patients had to prepare them on the basis of the ingredients prescribed by physicians. What was prepared by the patients often did not measure upto the prescription, both in content and method. Thus occurs a wide gap between what the physician intended and what was actually administered to the patient. So an effective mehtod to ensure the quality of medicine is needed otherwise even a competent physician would become ineffective.[6]

It was really a part of general cultural intellectual regeneration taking place during the late nineteenth and early twentieth centuries.

The movement in Kerala under the leadership of P.S. Warrier throws some light on these directions.

The efforts for the revitalization movement of Āyurveda revolved around three issues:

1. The retrieval, systematization and dissemination of knowledge.
2. The creation of institutional facilities for training physicians.
3. Preparation and distribution of medicine.

P.S. played a greater role in institution building and more importantly having a close connection with the cultural awakening in colonial Kerala.

Āryavaidyasamāja

As the first step to find a solution for some of the aforesaid problems, he himself took initiative and formed an association of physicians called the Āryavaidyasamāja[7] in 1902.

The Āryavaidyasamāja was essentially a voluntary public platform to exchange views and share experiences. In the process it became an ideal platform for the revival and strengthening of Āyurveda.

The inaugural session of the Samāja was held at Kottakkal with delegates from all over Kerala. Subsequently annual conferences were held in different places. The Maharajas of Travancore and Cochin and the Zamorin of Calicut were its patrons and P.S.Warrier was nominated as its permanent secretary.[8]

The Samāja contributed for the creative introspection into the past and the present of Āyurveda both in its knowledge and practice.

The proceedings of the meetings had two sections. The first comprises general speeches which shed light upon the past. This helped to build confidence in the system. The second is the reading of papers which led to more professional discussions on illnes, treatment and medicine.

This helped significantly to codify the uncodified experience and innovation of different physicians. It also helped much to unearth the problems and potentials of the discipline. The Āryavaidyasamāja was converted into the Kerala Āyurvedic Studies and Research Society in 1976 with professional and Governmental representatives.

Works

The codification and dissemination of existing knowledge was an area to which P.S. Warrier devoted considerable attention. The following are his works in Āyurveda: *Cikitsāsaṅgraha, Aṣṭāṅgaśārīra, Bṛhacchārīra* (2 vols), Malayalam rendering of *Aṣṭāṅgahṛdaya, Viṣūcika, Dhanvantari* (fortnightly in Malayalam) and *Āryavaidyacaritram.*

Cikitsāsaṅgraha

PS prepared and published a catalogue of medicines called *Cikitsāsaṅgraha* with details of usage, dosage and other information which would enable patients to use medicines even without the prescription of a physician. Moreover it helps to get acquaint the public with the rudiments of Āyurvedic medicines and treatment.

Viṣūcika

It is a book on cholera meant to popularise the ideas of Āyurveda regarding the disease of that name, its cause and cure. Once the area of Kottakkal was got afflicted by the disease. Then Warrier made use of the chance to introduce Āyurvedic medicine for the same and saved a large number of people of his village.[9]

Āryavaidyacaritram

This is a Malayalam work which deals with the history of Āyurveda jointly written with his cousin P.V. Krishna Warrier. This was perhaps the first history of Āyurveda written in an Indian language[10]:

These attempts made Āyurvedic knowledge easily accessible to the public as well as practitioners of the medicine.

Dhanvantari

To popularise Āyurveda among the public he has brought forth a journal called *Dhanvantari*[11].

It was a fortnightly published by P.S. Warrier from Kottakkal in 1902. It served as a tounge of revitalization movement of Āyurveda in Kerala.[12]

This provided an open forum for debates and discussions, as evident from some articles published in it.

He himself was a regular contributor. He emphasized righteous living in accordance with Āyurvedic principles.

He wrote a series of articles entitled the "Western and Eastern Medicine", which was really an eye opener assessment which brings out the strength as well as the weakness of both the systems. In

these writings he depicts the advance made by Western medicine, and emphasized the adoption of certain ideas and methods from it. He admires the past achievements as well as the divine origin of Āyurveda, but simultaneously stressed the need for it reformation.

While comparing both the systems he emphasized critically the relative merit and potential of Āyurveda for effective health care of Indians, as per the climatic conditions in which the body was located.[13] By these efforts made easier the retrieval of knowledge for the public and practitioners.

But bringing this process into practice is only possible, when this knowledge is internalized and incorporated by the existing practitioners.

Aṣṭāṅgaśārīra

A sound knowledge of anatomy and physiology is inevitable for medical studies, be it Āyurvedic or any other system. Regarding this Caraka states the following:

शरीरं सर्वदा सर्वं सर्वथा वेद यो भिषक् ।
आयुर्वेदं स कार्त्स्न्येन वेद लोकसुखप्रदम् ।।

For the study of anatomy and physiology he has translated the western books in respective fields. But with this he was not satisfied. In order to fulfill this wish he composed a book on anatomy and physiology called *Aṣṭāṅgaśārīra* otherwise called as *Laghuśārīra* which is an illustrated Sanskrit text book on anatomy and physiology.

This work is divided into 8 sections called skandhas. He himself taught the book to the students of pāṭhaśālā. It was published in 1926 in the All Iindia Conference of Āyurveda Physicians[14]. This book was recognized with a certificate of merit by the 16th plenary session of All India Āyurvedic Congress held at Jaipur in 1926.

Bṛhacchārīra

Bṛhachārīra is yet another work written by P.S. Warrier for

making efficient the teaching and learning of human anatomy and physiology.

This work is in two volumes. The first volume was published in 1942. It deals with embryology in 21 chapters. This is not a mere translation of any modern work on embryology. It is a well planned adaptation of modern teachings[15]. The second volume, *Asthiskandha* was published by S.R. Iyer in 1969. It consists of 10 chapters. Here he has done a great contribution to Āyurveda literature by coining many technical terms[16].

Āryavaidyapāṭhaśāla

The institutional arrangement for teaching and learning was realized by the setting up of a pāṭhaśāla at Calicut on 14 January of 1917. It was at the fifteenth annual meeting of Āryavaidyasamāja.

The objective of the same was clearly stated in its prospectus: "to revive the once prosperous and now increasingly declining Āyurveda", to bring about timely changes in it, to provide physicians with sufficient knowledge and experience who can conduct practice without others, assistance and to acquaint the British Government with the merits of indigenous system[17].

The emphasis is given for mastering Āyurveda texts and through that acquiring knowledge of medicine and their preparations. They were supplemented with instructions in physiology, anatomy, chemistry, midwifery and surgery incorporated from the western system[18].

This pāṭhaśāla was shifted to Kottakkal in 1924 and several hundred professionally qualified physicians came out of it.

This was later affiliated to the University of Calicut and renamed as the Vaidyaratnam P.S. Warrier's Āyurveda College and is managed by the Kerala Āyurvedic Studies and Research Society with the financial support from Āryavaidyaśāla, Kottakkal.

Āryavaidyacikitsāśāla

In 1924 P.S.Warrier established Āryavaidyacikitsāśāla[19] (the present charitable hospital) with inpatient and out patient services. It also had a separate allopathic wing. Presently, this hospital provides free OP services to a number of patients.

Āryavaidyasāla, Kottakkal

The most successful institution building effort of P.S. Warrier was in the field of manufacturing and marketing of medicines. He realized that Āyurveda treatment could be effective only if its medicines keep its own standard.

For fulfilling this urgent need, he established the Āryavaidyaśāla at Kottakkal on 12th October 1902. It was the first of its kind in South India[20].

Then P.S. Warrier issued a manifesto setting forth his objectives and suggested that some of the learned Āyurvedic physicians joined together and promoted a company on co-operative basis with the object of manufacturing Āyurvedic medicines and preparations on strict Āyurvedic principles, taking very good care to select the right ingredients after proper test and thus determined to follow the example of Allopathy with profit.

It is with this aim in view that P.S. Warrier established Āryavaidyaśāla where patients were examined carefully and treatment prescribed with great thought. Scientifically prepared medicines were supplied to patients as well as medical practitioners at reasonable prices. Arrangements were made for preparing and stocking medicines on the western mode without causing any damage to their quality and purity.

His progressive outlook and noble ideas are reflected in the manifesto brought out by him.

The Āryavaidyaśāla is a charitable institution under the will of P.S. Warrier under which the entire earnings from the working of the Institution are to be utilized for charitable purposes only. As stated in the will, the net surplus is now utilized for the following charitable

purposes: (1) Development of Āryavaidyaśāla by improving the facilities for treatment of inpatients and preparation of medicines, including research in various kinds of drugs and conducting seminars on Āyurveda. (2) Treatment of poor patients through the Charitable Hospital providing medicines, food, clothing etc. free to such inpatients. Treating of outpatients by giving medical advices and medicines free of cost. (3) Giving financial assistance to the Āyurveda College, Kottakkal.

In recognition of the valuable service rendered by him, he was conferred the title Vaidyaratnam by the Govt. of India in the New year Honours of 1933.

Indeed, P.S. Warrier stood for wholesomeness even in his wordly life. How can one explain his fourfold role as a phycisian, a playwright, an actor and a community leader.

Assessing P.S. Warrier's contribution to Āyurveda really is not an easy task. His legacy needs to be perceived at a more fundamental and philosophical level. Viewed in this way, P.S. Warrier's greatest contribution lay in removing the distorted image of Āyurveda as "non-living body of knowledge" squarely belonging to the realm of 'tradition'.

He changed this impression by selectively modernising Āyurvedic traditions and putting Āyurveda on the path of an enlightened competition with Allopathy.

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Elephantology

P. Narayanan Namboodiri

Ancient Indian scholars of animal husbandry have drawn special attention in depicting the life of elephants. Elephants are considered as one of the main constituents of the strength of an army. The intelligent use of elephant force in battle has given victory for several kings like Pulikeśin II and Bhūvikrama (635-679 AD). Rulers of the South were assumed titles like Gajapati in accordance with the number of elephants they possess and the battles they won by elephant force.

Arthaśāstra is the oldest book which says about hastivana and nāgavana (Royal Elephant Sanctuaries) and stipulates how elephants are to be looked after. The propounders of Āyurveda have considered a special branch of Indian veterinary science called hastyāyurveda. *Bṛhatsamhitā* of the Gupta age has devoted a separate chapter for showing the characteristic marks of elephants. The western Gaṅgā king Durvinīta of 8th centuary AD is credited with a work called *Gajaśāstra*. The catching and training of elephants are the subjects dealt with in the encyclopediac work called *Abhilaṣitārthacintāmaṇi* attributed to Cālūkya king Someśvara III (1126 - 1138). It also describes the forests in South India where elephants are seen plenty in number. *Hariharacaturaṅga* of Godavarmamīśra, a court poet of Pratāparudra Gajapati (14971 -1551) contains different characteristics of elephants in its first chapter. The *Śivatattvaratnākara* attributed to Keladi chief Basava of Kannada describes various kinds of elephants. *Gajagrahaṇaprakāra* of Nārāyaṇa Dīkṣita is a treatise to

illustrate the method of catching of elephants and their training. *Gajaśikṣā* of Nārada is another work which eleborates 28 types of elephants all over the earth. Two chapters of this book are devoted to explain the method of catching, preparing the abode of elephants etc. *Mātaṅgalīlā* of Nīlakaṇṭha is the best available Sanskrit work on elephantology. G.P Sanderson has produced a book called *Thirteen Years among the Wild Beasts in India* in 1879. He was in charge of elephant catching service of the State of Mysore and of the Govt of Bengal. F. Edgerton has translated the work *Mātaṅgalīlā* by name *The Elelphant lore of Hindus* (1931).

Here an attempt is made to bring forth the principles of Elephantology depicted in *Mātaṅgalīlā, Gajaśikṣā* and *Gajagrahaṇa prakāra*. *Mātaṅgalīlā* is a short work consisting of 263 verses in twelve chapters. Science of elephants is vividly explained along with the caste classification of elephants in the first chapter. Favourable and unfavourable marks of elephants are discussed in second chapter. This classification is made on the basis of colour, length, height, sensitivity and above all the remarks regarding their age. The author has also advised the king not to take a female with a young one which will seriously hurt the wealth of the country. The best among the elephants taken by the kings are those which can carry the king and fight in the battle: "Vāraṇāstu narendrārhā yudhyanti ca vahanti ca".

The next chapter explains the longevity, state and best types of elephants. Different stages of life are depicted in the next one. The animal is named differently according to their age and deeds. The standard measurements of each of the three main casts, length, height etc are described in the following chapter. The next chapter which is the smallest one illustrates the way to calculate the price of elephants in accordance with their quantities. The subject of the marks of character is dealt with in the eighth one. Classification is made according to the varying degrees of sensitivity to act as per the commands of the mahouts. Chapter nine, one of the important chapters in the text, elaborates the state of must (mada). The most striking symptoms of mada is certainly

the discharge of a sweetish sticky fluid from the temporal glands which are situated on either side of the forehead. *Mātaṅgalīlā* states that this liquid will flow from eyes, palate, temples, ears, navel, trunk and nipples and even from the hairs of the body. It also narrates that the first sight of this mada in the right temple indicates that victory is the result. If it is seen on the left side, the earth will be greeted by enough rainfall. Chapter X is devoted for explaining the methods of elephant catching. *Mātaṅgalīlā* narrates five methods such as vāribandha, vaśābandha, anugati, āpāta and avapāta. Among these methods the later methods are comparatively blamable.

In a vast area where sharp sticks are planted around the pitch covered with leaves and other eatable plants wild elephants are driven into the place and clever mahout waiting on the trees will try to close the pen. Thus they are trapped. After selecting the remarkable qualities in them with the help of female elephant they are shifted to sheds. This method is vāribandha.

Take five or six reliable female elephants and cover their backs with leather. Elephant herders shall hide under these skins armed with ropes. Then striking them with their ropes they shall drive the animals straight to a herd and shall quickly tie up five or six elephants. This method is done by seduction. Some medicines for seduction of wild ones are also pointed out here. This is vaśābandha.

With sounds of kettledrums, musical instruments and drums driving apart the elephants, the herders always with a crowd swiftly and fearlessly persuing the greatly frightened animals when the young are lame with foot weariness shall then quickly and cleverly catch them. This is called anugati or pursuit.

Now, the āpāta method. Placing there on stalks and lotuses, bamboo, plantain trees, white sugar cane and tying those ropes also to a stout tree, then clever herdsmen lying in wait in concealment shall quickly catch the elephants while they are engaged in eating.

The last method, avapāta which is not advisable due to its

result, is catching them by making huge pits covered with plants and sugar cane. It always cause even the death of young ones who fell in it.

Chapter eleven explains the principles of keeping of elephants in detail. Food items according to the age, medicines on particular occasions, special attention at the time of rut are some important points given in this chapter. The nature and characteristics of the managers of elephants, trainers and drivers are interestingly emphasised in the twelfth chapter. The training method by words and deeds, parts of the body where a driver can beat, instruments for punishing the animals, proper time for punishing the animals, different types of drivers are all elaborately discussed here. *Mātaṅgalīlā* attributes the qualities of a driver thus: He should know three types of elephants, three types of punishments, three types of motions, three types of sitting, six ways of using sticks, five types of walking, eight types of climbing and ten types of stepping down.

Gajagrahaṇaprakāra in five chapters is a small book of Nārāyaṇa Dīkṣita which illustrates ten methods of catching animals such as vṛti, vṛkṣa, rajju, vāri, anugata, laghugarta, nimnavata, codana, vana and pañcalikā. Most of these methods are similar to those explained in *Mātaṅgalīlā*. According to Nārāyaṇa Dikṣita vanabandha is the most acceptable one where tamed elephants are sent to forest for bringing them to artificial pools where they are caught by clever mahouts. By using puppets the young ones are captured in the method of pañcalikā.

"The supervisor of elephants should be intelligent, king-like, righteous, devoted to his lord, pure, true to his undertakings, free from vice, controlling his senses, well behaved, vigorous, tried by practice, delighting in kind words, learned from a good teacher, clever, firm, affording protection, renowned for curing diseases, fearless, and all knowing".

Hard for foes to conquer is an elephant driver who is clever at the ways of mounting and dismounting from elephants, at sitting by means of seats on the showlders and the hind parts, at driving them with the voice feet and hook, at the methods of marching and running them

through streets and in the country, at turning them back as stopping them and at fighting with hostile elephants.

The first and second chapters narrate the types and qualities and the method of catching in detail. The third chapter gives an account of forests where elephants are found plenty in number. The training of elephants are the content of the next one. The need of exhibition of elephants in every year is also explained.

This small book is the first of this type where the method of catching and training are vividly described.

Gajaśikṣā of Nārada is an incomplete work divided into nine chapters. In this book 28 types of elephants found all over the world are classified in the second chapter. Noble, middle and low classes are considered according to their origin. The following three chapters say about the method of capture. Seventh chapter deals with the construction of abodes for both animals and their keepers.The last two chapters bring forth the ideas of growth, seasonal diseases, common characteristics and different phases of training.

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Thoughts on Biodiversity and Conservation in Ancient and Medieval Sanskrit Literature

N.V.P.Unithiri

Vṛkṣāyurveda is a branch of knowledge which was given very much importance in Sanskrit literature of ancient and medieval India. The term 'vṛkṣāyurveda' literally means 'the knowledge of tree life'. This discipline deals with plant pathology or treatment of trees in general. It includes concepts of biodiversity and conservation. Here an attempt has been made to present a few pieces of information regarding this subject with special reference to the vṛkṣāyurveda chapters of *Bṛhatsamhitā* of Varāhamihira (*BS*, 6th century A.D) and *Samhitā* of Śārṅgadhara (14th century A.D).

The discipline of vṛkṣāyurveda has a long history in India. Reference to disease of plants and their treatment can be seen in *Atharvaveda* (1200 B.C). *Atharvaveda* 29.7 mentions the destruction of corn by pestiferous insects. The commentator Sāyaṇa (14th century A.D) provides a long list of insects who destroy crops. A separate section by name gulmavṛkṣāyurveda occurs in Kauṭilya's *Arthaśāstra* (3rd century B.C). *Carakasamhitā* (kalpasthāna, chapter1) and *Suśrutasamhitā* (sūtrasthāna, chapter 37), (both of 2nd century A.D) and some other Āyurveda texts prescribe vegetable drugs depending on the nature of soil.Treatment of plant disease is seen in *Agnipurāṇa* (2nd century). *Amarakośa* (5th century) contains a section

entitled 'auṣadhivarga' on flora and fauna which is directly connected with *vṛkṣāyurveda*. There are some other works also like *Vṛkṣāyurvedas* of Surapāla or Sureśvara and Parāśara (12th century). *Kṛṣiparāśara* by Parāśara and *Kṛṣisūkti* by Kaśyapa are some of other tracts dealing with certain aspects of plant pathology. The various stages of growth of plant life, resistance to diseases and recovery from wounds by the application of drugs are dealt with by Guṇaratna (15th century) in his commentary on *Ṣaḍdarśanasamuccaya*. Tantra works like *Paddhati* by Īśānaśivagurudeva (12th century) and *Tantrasamuccaya* by Cennas Narayanan Namboodiripad (15th century) and architectural treatises like *Manuṣyālayacandrikā* by Tirumangalam Nilakanthan Moosad (16th century) and *Śilparatna* by Śrīkumāra (16th century) treat some aspects of vṛkṣāyurveda.

Worshipping trees and plants was an essential part of ancient Indian culture. Big groves known as 'nāgas' (short form of nāgavana or sarpakkāvu / kāṭu) were the places of such worship in ancient and medieval Kerala. According to tradition[1] each and every person, who wishes to live long, should protect the tree assigned to his birth star. The verses run as follows:

विषवृक्षामलकतरुदुम्बरजम्बूश्च खदिरकृष्णौ द्वौ ।
वंशाश्वत्थौ नागो न्यग्रोधपलाशकौ प्ळक्षः ।।
अम्बष्ठश्रीवृक्षावर्जुनवैयङ्कतौ बकुळविष्टी च ।
सर्जो वञ्चुळपनसावर्कशमीकौ कदम्बचूतौ च ।।
तालमधूकावेवं नाक्षत्राः शाखिनः प्रोक्ताः ।
आयुष्कामः स्वीयं नक्षत्रतरुं सदा रक्षेत् ।। (XVII.76-78)[2]

The following is the list of 27 stars along with the trees assigned to them: [3]

1. अश्विनी (अश्वति)	विषवृक्षः (काञ्ञिरम्)	Strychnos nuxvomica
2. भरणी	आमलकः (नेल्लि)	Emblica officinalis
3. कार्तिका	उदुम्बरः (अत्ति)	Ficus racemosa
4. रोहिणी	जम्बूः (ञावल्)	Syzygium cumini

5. मृगशीर्षः (मकीर्यम्)	खदिरः (करिङ्ङालि)	Acacia catechu
6. आर्द्रा (तिरुवातिर)	कृष्णः (करिमरम्)	Diospyros ebenum
7. पुनर्वसुः (पुणर्तम्)	वंशः (इल्लि)	Bambusa vulgaris
8. पुष्यः (पूयम्)	अश्वत्थः (अरयाल्)	Ficus religiosa
9. आश्ळेषा (आयिल्यम्)	नागः	Mesua ferrea
10. मघा (मकम्)	न्यग्रोधः (पेराल्)	Ficus bengalensis
11. पूर्वफल्गुनी (पूरम्)	पलाशः (प्लाशु)	Butea monosperma
12. उत्तरफल्गुनी (उत्रम्)	प्ळक्षः (इत्ति)	Ficus microcarpa
13. हस्तः (अत्तम्)	अम्बष्ठः (अम्बषम्)	Spondias pinnata
14. चित्रा	श्रीवृक्षः (कूवळम्)	Aegle marmelos
15. स्वाती (चोति)	अर्जुनः (नीर्मरुतु)	Terminalia arjuna
16. विशाखा	वैयङ्कतः	Flacourtia jangomas
17. अनुराधा (अनिषम्)	बकुळः (इलञ्ञि)	Mimusops elengi
18. ज्येष्ठा (तृक्केट्ट)	विष्टिः (वीट्टि)	Aporosa lindleyana
19. मूला	सर्जः (वेङ्ङ)	Pterocarpus marsupium
20. पूर्वाषाढा (पूराटम्)	वञ्जुळः (अशोकम्)	Saraca asoca
21. उत्तराषाढा (उत्राटम्)	पनसः (प्लावु)	Artocarpus integrifolia
22. श्रवणः (तिरुवोणम्)	अर्कः (एरुक्कु)	Calotropis gigantea
23. श्रविष्ठा (अविट्टम्)	शमीकः (वञ्ञि)	Salix tetrasperma
24. शतभिषक् (चतयम्)	कदम्बः (कटम्पु)	Anthocephalus chinensis
25. पूर्वभाद्रपदा (पूरुट्टाति)	चूतः (मावु)	Manjifera indica
26. उत्तरभाद्रपदा (उत्रट्टाति)	तालः (करिम्पन)	Borassus flabellifer
27. रेवती	मधूकः (इलिप्प)	Madhuca longifolia

it can be concluded that as a result of this belief, different types of trees were protected, thereby ensuring biodiversity.

Manuṣyālayacandrikā (1.23-26) gives the desirable and undesirable positions of trees in the compound of a residential building. Trees with thick foliage are recommended to be planted in the north of the house to resist the cold winds from that side. Trees which shed leaves like tamarind (Tamarindus indica) and those without thick foliage like areca (Areca catechu) are to be planted in the south to allow sunlight during winter season, when the sun is moving in the

southern hemisphere. Fruit bearing trees which are generally of hard wood-core type can be planted very near to the house. Trees whose contact causes allergy like cerumaram (Semecarpus anacardium) and certain trees which are not auspicious like kāññiram should not be planted anywhere in the plot. Based on structure, trees are divided into four in accordance with the position of hard wood, namely, antassāra (hardwood at core), bahissāra (hard wood outer side), sarvasāra (hardwood throughout) and nissāra (soft wood). Antassāra type of trees like jack (Artocarpus integrifolia) should be planted nearest to the house, sarvasāra trees like tamarind outside them and the others far outside.

Chapter 29 of *Bṛhatsamhitā* is called kusumalatādhyāya (chapter on flowers and creepers). The topic of this chapter is the phenological observation of flowers and trees of certain plants as indicators to predict the productivity of crops and the related aspects of agricultural climatology. It is stated that from the luxuriant growth of flowers or fruits of certain kind of trees, a large quantity of crops of a particular cereal or pulse, metals, things and persons can be predicted.[4] The following list showing prognostication can be prepared from the observation made in verses 2-14 of this chapter. The presence of some plants serves as indicator for the growth of some other plants etc. as shown below:

Indicator Plants	Possible Crops, etc.
Sāla tree (Shorea robusta)	- kalama rice (Oryza sativa)
Raktāśoka (Saraca asoca)	- redrice
Kṣīrikā (Alstonia venenata)	- pāṇḍuka rice (Sterculia urens?)
Nīlāśoka	- sukaraka rice (Gironniera enspidata?)
Banyan (Ficus bengalensis)	- yavaka rice (Hordeum vulgare)
Ebony (Diospyros ebenum)	- ṣaṣṭikā rice (a kind of rice growing in 60 days)
Aśvattha (Ficus religiosa)	- all crops in general
Jambu (Syzygium cumini)	- sesamum and black gram
Śirīṣa (Albizia lebbeck)	- panic seed
Madhuka (Bassia latifolia)	- wheat
Saptaparṇa (Alstonia scholaris)	- barley
Atimuktaka (Chrysanthemum indicum) and Kunda (Jasminum multinum)	- cotton
Asana (Bridelia montana)	- mustard
Badari (Ziziphus jujuba)	- horse gram
Cirabilva (Pongamia pinnata)	- green gram
Vetasa flower (Calamus rotang)	- linseed
Palāśa (Butea monosperma)	- kodrava (varaku in Mal. (Paspalum scrobiculatum)
Tilaka tree (Cerodendrum phlomoides)	- conch, pearl, silver
Iṅguda (Balanites aegyptiaca)	- hemp
Hastikarṇa (Alocasia macrorrhiza)	- elephant
Aśvakarṇa (Shorea robusta)	- horse
Pāṭala (Stereospermum scaveolens)	- cows
Kadali (Musa paradisiaca)	- goats and sheep
Campaka flower (Michelia champaca)	- gold
Bandhujīva (Pentapetes phoenicea)	- coral
Kuravaka (Baleria aristata)	- diamond
Nandikāvarta (Tabernaemontana coronaria)	- vaidūrya (Lapis lazuli)
Sindhuvāra (Vitex trifolia)	- pearl
Kusumbha (Crocus sativus)	- artisan
Suvarṇapuṣpa (Cassia fistula)	- trader
Lotus (Nelumbo nucifera)	- brāhmaṇas
Water lily (Nymphaea stellata)	- priests

Saugandhika (Nymphaea lotus)	- army chief
Arka (Calotropis gigantea)	- increase of gold
Mango tree (Mangifera indica)	- welfare
Bhallātaka (Semicarpus anacardium)	- fear
Pīlu (Salvadora obovoides)	- health
Khadira (Acacia catechu) and Śamī (Prosopis spicigera)	- famine
Arjuna (Terminalia arjuna)	- good rain
Picumanda (Azadirachta indica) and nāga (Mesua ferrea)	- wealth
Kapittha (Feronia elephantum)	- wind
Nicula (Calamus rotang)	- fear of drought
Kuṭaja (Holarrhena antidysenterica)	- threat of disease
Dūrvā (Cynodon dactylon) and kuśa (Desmostachya bipinnata)	- sugarcane
Kovidāra (Bauhimia variegata)	- fire
Syāmālatā (Echinochloa frumentacea)	- concubines

It is the responsibility of modern scientists to investigate whether there is any scientific base for these predictions or not. Now we may look into the vṛkṣāyurvedādhyāyas of *Bṛhatsamhitā* and *Śārṅgadharasamhitā*. These are exhaustive chapters covering all the essential aspects of the life of trees and plants. These chapters which can be said as botanical treatises discuss the following subjects:

(1) Importance of planting trees
(2) Plant gardening
(3) Protection of trees
(4) Propagation of plants
(5) Fertilizers
(6) Preservation of seeds
and
(7) Pests and disease management

1. Importance of Planting Trees

At the outset of vṛkṣāyurveda chapter of *Bṛhatsamhitā*, Varāhamihira makes us aware of the importance of laying out gardens on the banks of tanks and lakes because they will not be beautiful without shade on their sides[5]. It is clear from this prescription that both reservoirs and gardens are mutually beneficial. From the view point of tourism too, this is significant and thus even today this observation has very much relevance. In this connection, it is to be noticed that Śārṅgadhara praises the glory of trees. In fact, in his vṛkṣāyurveda chapter of *Śārṅgadharasamhitā* he devotes a whole section for this topic (Tarumahimā, *SST*, verses 4-23). There we have the following:

Better to have a tree planted by the way side where many rest under its shade, than to have many sons born who are devoid of wealth and virtue[6].

Excavation of a pond is equivalent in virtues to sinking of ten wells, a lake is equivalent to ten ponds, and a son is equivalent to ten such lakes; and a tree is as good as ten sons.[7]

Then Śārṅgadhara proceeds to highlight the virtues of planting some particular kinds of trees.

We have already seen that *Manuṣyālayacandrikā* also takes into consideration the importance of planting trees in the compound of a residential building.

2. Plant Gardening

BS holds that before planting trees and plants soil of the ground should be prepared. Instead of using pesticides which creates many pollution problems, there was a traditional method according to which sesamum seeds were sown in the field and when their plants were in bloom they should be crushed and mixed with the soil[8].

SST also prescribes the same method. The author says that one should sow pulses and sesamum on a level ground after it has been thoroughly ploughed with a plough and should cut the crops when they are ripe and then should sow seeds on that ground again[9].

According to modern scientific investigations, the root of sesamum creepers bear minute germs and such germs release nitrogen alkalies and later on helps the growth of plants to be cultivated in the field. This eco-friendly method is relevant even today.

Then *BS* gives a list of auspicious trees and creepers to be planted first in gardens or compounds of houses. The list contains neem (Azadirachta indica), aśoka (Saraca asoca), punnāga (*Calophyllum inophyllum)*, śirīṣa trees and priyaṅgu (*Agalaia roxburghiana)* creeper. Kaśyapa adds to this list some other titles also, namely, campaka, udumbara (*Ficus racemosa*) and pārijāta (*Erythrina indica*). Further, these are recommended by him to be planted in temple premises too[10].

According to *SST* the presence of Banyan tree in the east of a house fulfil all desires; udumbara in the south, pippala (*Ficus religiosa*) in the west and plakṣa (*Ficus microcarpa*) in the north will provide good, and everything else should be strictly forbidden[11]. He further maintains that one should avoid aśvattha (*Ficus religiosa)* in the east of a house, plakṣa in the south, Banyan in the west and udumbara in the north[12]. What is the rationale for this prescription is not explained. Whether there is any scientific reason for this is also to be investigated. It is noteworthy that *SST* objects planting any tree in front of a house. The idea of the relevant verse runs as follows: One should avoid the shades of all trees in one's house; one should not plant in front of one's house a tree even it is made of gold[13]. Likewise *SST* prohibits making of a garden in the south-west or south-east corner of a house. He says that distress and sorrow will be its outcome[14].

When we plant trees, sufficient distance must be kept between two trees in a compound or garden. According to *BS* in the case of big trees the most desirable distance is 14 1/2 metres. 11 1/2 metres is moderate and it is inferior if it is 8 1/2 metres.[15] Reason for this is that trees growing closely and touching each other with their roots interlocked do not yield much.[16]

On this topic, *SST* gives some more details. It says that one should lay out the trees in a garden so as to look an altar, a circle, a svastika,

a square, a sarvatobhadra, an avenue, a grove-bower and in clusters[17]. The distance between trees recommended by *SST* is more or less the same as by *BS*. The only difference is in the case of inferior. While *BS* recommends 8 1/2 metres, *SST* recommends 7 metres (65 ab). *SST,* however, adds to this that if the surface of the garden be plane one should plant grass-like plants at an interval of 1 1/2 metres and 3 metres and bushes at 2 metres[18]. He further points out that trees, if thickly sown, are hindered in their growth and if sown very sparcely, they are in danger of falling down even in consequence of mild winds[19]. *SST* closes this section enjoining that one should plant trees with an eye to the fact that there is room for the spread of their roots and one must see that the leaves of each other do not touch.[20]

3. Protection of Trees

This topic is not dealt with in *BS*. But *SST* devotes two sections for its treatment. It prescribes rules for watering plants and protecting trees. One should water the newly planted trees both in the morning and evening. They should be systematically protected from cold, stress, and wind.[21] Water the trees and plants every alternate day in autumn and in winter; everyday in spring, and twice a day during the summer.[22] During the rainy and autumnal season when it does not rain one should fill the circular ditch under the tree with water.[23] Pour water till the earth attached to the roots of the tree becomes wet; don't mind about the quantity of water applied for this purpose.[24] Since trees suffer from indigestion if the water in the ditches is not dried up, one should not pour fresh water in it till such is the case.[25] *SST* also prescribes that, in the interest of trees, one should extirpate the weeds, creepers and shrubs which grow beside them.[26] Trees should carefully be protected from destructive influence of dew, strong wind, smoke, fire and spiders.[27] Trees should be well protected with walls having ditches around them.[28] Now we may look into a very interesting prescription by *SST* that one should take up the ashes of trees struck by lightning, throw the same around other trees and this will ensure the latter against cold. It says that these ashes have the power to allay even the burning fire.[29] Another prescription runs as follows: Throw boiled white śālī

rice mixed with curd and rock-salt round the trees. It will ensure their protection from poisonous or harmful rain.[30]

4. Propagation of Plants

Four methods for propagation of plants are described by both these authors: (a) Transplantation, (b) Sowing, (c) Cutting, and (d) Grafting.

(a) Transplantation

This is called samkrāmaṇa-viropaṇa. It means planting trees after bringing out them from another place. This method has a long history in India. During the reign of Aśoka very rare medicinal herbs, roots and fruits were imported and transplanted wherever they were not existent. Before replanting, necessary care should be taken to avoid the menace of pests. For this, a kind of ointment is recommended which is made of mixing equal quantity of ghee, uśīra (Vetiveria zizanioides), sesamum, honey, viḍaṅga (Embelia ribes), cow's milk and calf-dung.This ointment should be applied top to bottom of the tree to be transplanted.[31] The time of replanting is also stipulated by ancient Indian agriculturists. *BS* maintains that trees having undeveloped branches are to be planted in cold season (January- February), those having developed branches in winter season (November- December) and those having well-developed stems in rainy season (July-August)[32]. Kaśyapa also holds the same view.

On transplantation *SST* says:[33] One should first of all sow seeds in the sea bed, spread grass over it and sprinkle milk and water, and then when seeds germinate remove the grass, dry the earth a little, and transplant these sprouts together with their roots and the earth attached thereto.When a sprout planted after being sprinkled with milk grows about 2/3 metre in length, one should dig it out together with the earth attached thereto and apply to it roots of uśīra, viḍaṅga and ghee pasted together and then replant it in a pit together with cowdung.[34] The idea of three verses of *SST* also are to be quoted in this connection: One should plant a tree seedling in a pit 1½ metre in depth, well watered, filled with fine dusts of earth free from sands, and filled with cowdung.

Plantain sprouts and trees with milky sap should be planted only after applying cowdung to the roots.[35] First of all one should plant and besmear a long straw rope with this paste thus prepared, then put the rope thus treated with banana paste down in the ground lengthwise. Then for a long number of days one should go on sprinkling water upon it little by little.[36] Then, sprouts having bluish and reddish appearance like the fresh tamāla tree will sprout out of that rope; and then when by degrees branches, leaves and roots will become visibly manifest, one should plant these sprouts, elsewhere and sprinkle water upon them.[37] This is said to be called 'parṇayoni' method. Even now, in rural areas, this kind of transplantation appears to have been followed.

(b) Sowing

On the subject of sowing *BS* s prescription is as follows: Soak the seeds in milk for ten days. Take them daily with your hand besmeared with ghee.Then role them many times in cow-dung. Fumigate them with flesh of hog and deer. With flesh and hog's marrow sow them in the soil that is already prepared with the sesamum treatment. Sprinkle over them by milk and water. No doubt, they will grow and bloom soon.[38] Even the seeds of tamarind having hard shells will sprout, if they are watered by the mixture of flour of rice, black gram, seasmum, barley gruel along with rotten flesh and fumigated constantly by turmeric powder.[39] In the case of wood apple (kapittha) seed, the following process is prescribed: roots of wild jasmine, āmalaka (Emblica officinalis), dhava (Anogeissus latifolia) and vāsikā (Adhatoda vasica), creepers and leaves of Vetasa tree, sūryavalli (Indigofera enneaphylla?), śyāmā and atimuktaka, all of these on the whole is known as aṣṭamūlī (eight roots). Boil this aṣṭamūlī in milk and cool it. Then soak the wood-apple seeds in this liquid for a period of time equal to that of 100 beats of the hand.Take them out, dry them in the sun. Daily repeat this for a month. Then sow the seeds according to the following method: Dig a pit with the diameter of 72 cm. and the depth of 144 cm. and fill it with milk and water. Dry it up. Burn it. Fumigate it (pit) with the mixture of honey, ghee and ashes. Then fill it upto 120 mm with mud. Put over it the mixture of the powders of blackgram, sesamum and barley. Again

put mud and the mixture once more.Then pour on it an infusion of fish and water. Then pound all this until the things of the pit becomes a thick mass. (More or less the same process is followed even now when we make compost manure). Then sow the seed of the tree 120 mm deep in the pit. Sprinkle it with fishwater and flesh water.The creepers will be flourished with sprouts soon.[40]

For the sowing of the seeds of trees, certain stars are believed to be auspicious. They are dhruva stars, namely uttram, uttrāṭam and uttraṭṭāti and rohiṇī, and mṛdu stars namely, anizham, citra, makīryam and revatī, and six other stars, namely, mūlam, viśākham, pūyam, tiruvoṇam, aśvati and attam.[41] 58th verse of *SST* is, in fact identical with this. Perhaps he has quoted it from *BS* itself. It is to be investigated whether any scientific basis is there in this observation.

(c) Cutting

Jack tree, aśoka, plantain, jambū, lakuca (āññili-Artocarpus lakucha), dāḍima (Punica granatum), drākṣā (grape), pālīvata, citron tree and jasmine creeper, these are to be planted after cutting their stems smeared with cowdung.[42] According to *SST* tāmbūlī, sindhuvāra, tagara (Valeriana wallichii) and such others grow out of kāṇḍa, portion of stems, ie.cuttings. pāṭala, dāḍima, plakṣa, karavīra (*Nerium indicum*), vaṭa and such others, mallikā, udumbara, kunda (*Jasminum multiflorum*) and others grow out of seeds and cuttings.[43]

(d) Grafting

For the propogation of trees grafting is another means mentioned in *BS*. The work recommends two methods for grafting technique: (i) Inserting the cutting of a tree into the root of another, cut off from its trunk, and (ii) inserting the cutting of a tree into the stem of another.[44]

It is Utpala, the commentator, who explains these two methods clearly.[45] Utpala adds to this that the junction of the two in both these cases is to be covered with a coating of mud (atra mṛttikāśleṣam dāpayet). Later we see that *SST* develops another method

which can be called 'parṇayoni' (transplantation through leaves). It is through leaves, instead of roots or stems (Relevant verse has already been quoted with translation in the section of 'transplantation'). This is observed to be corresponding to the modern method of tissue culture (Manoharan, 1996, *Bṛhatsamhitā - A Critical Study,* unpublished Ph.D. Thesis, Dept. of Sanskrit, University of Calicut, p.209).

5. Fertilizers

BS prescribes a special recipe for increasing the yield of flowers and fruits of trees and plants.The manure consists of a mixture of five litres each of the powder of dung of goats and sheep, five litres of sesamum powder,1.25 litres of wheat particles, 9 litres of beef and 20 litres of water kept for seven nights. Trees, plants and creepers should be watered by this liquid mixture in all seasons.[46] Kaśyapa also recommends the same manure for the speedy growth and increasing the yield of trees and plants. Some other relevant points connected with preparation of fertilizers have already been referred to in a previous section ('sowing').

It is on the prescription and preparation of fertilizers that *SST* makes substantial contribution. It prescribes a kind of nourishing solution called kuṇapajala which is very much healthy for plants in general. Preparation of this liquid mixture is described as follows: Boil the flesh, fat and marrow of deer, pig, fish, sheep, goat and rhinoceros in water; when it is properly boiled, put the mixture in an earthern pot; add into it milk, powders of sesamum oil-cakes, black gram boiled in honey, the decoction of pulses, clarified butter and hot water (It is to be noted that there is no fixity as to the quantity of any of these ingredients); put the pot in a warm place for a fortnight. Then you will have kuṇapa water.[47]

In the verses 147-170, *SST* prescribes manures specifically for the growth of separate trees and plants.The following list can be summed up from these verses:

Names of plants	Prescribed manure
Date palm (Phoenix dactylifera), bilva (Aegle and marmelos), and lakuca trees	- Application of powdered oil cakes of white mustard or sesamum at the root
Mango tree	- Pouring water in which husks are soaked
Orange (Citrus spp.) and vetasa	- Simple watering, watering with flesh and paddy washings
Old Indian gooseberry (Emblica officinalis)	- Blackgram (Phaseolus mungo)
Young gaubpersimmon (Diospyros embryopteris)	- Application of water and milk
Coconut tree	- Application of barley powder
Mango trees bear very fragrant and sweet fruits at an early date	- Watering with decoction of milk leaves of five trees (mango, ficus racemosa, ficus religiosa, ficus bengalensis and ficus microcarpa) together with the fat of deer, boar, jackal, horse, elephant etc.
Dāḍima tree	- Decoction of clarified butter, kuṇapa water, sweetflag and pig's stool (favourable to development of fruits); decoction of powders of horse gram (favourable to the roots)
Kadamba (Anthocephalusmixture-cadamba) Nāgakesara (*Mesua ferrea*) tree	- Watering with the liquid made of curd, fermented rice water wine made out of rice, plum, seasmum, methi, kuṇapa water and wine prepared from sugar and milk
Nāgakesara or champak	- Filling the trenches around the tree with the decoction made up of priyaṅgu, Indian liquorice, neem, Indian long pepper, sweet flag, turmeric, sesamum and mustard all taken equal parts

of	together with clarified butter and broth Sal tree (bark)
Grape wine	- The compound liquid made up of stools of fowls, straw and husks of paddy
Jackfruit tree	- Besmearing the trunk of the tree with one compound 6 maunds and 10 seers of gāruḍī creepers with leaves; and watering the roots of it with the broth of sweet flag.
Wood apple tree or bilva	- Watering with clarified butter, milk and honey
Madhuca longifolia	- Watering with the compound made up of the broth of roots and leaves of kōśātakī, Long pepper, kuṇapa water and powdered resin
Plum tree	- Watering with the decoction of sesamum and liquorice and with kuṇapa water
Bījapūra tree (Citrus medica)	- The compound substance of the stools of goat, sheep, pig etc. viḍaṅga, and the stools of men; urine of horses and sheep.
All creepers and	- Piercing the roots with stings of scorpion, fumigating with clarified butter watering with the fats of mice and pig.
Screw pine	- Watering with the wine of cows and kuṇapa water in summer
A barren lotus	- Application to the roots, the compounded dust of horse gram and tusks of elephants
Trees in general	- Besmearing the trunks with mustard, plantain leaf, Safari fish, stools of pig and cat in equal parts mixed with clarified butter; fumigating them

"	- After fumigating them with barley, wine, fermented rice water and clarified butter; besmearing their trunks with cakes made up of viḍaṅga and sesamum bathed either in milk or kuṇapa water
"	- Application of the decoction of aṅkola (alangium decapetalum) flower mixed with clarified butter and honey, fats of deer and boar added to, powders of white mustard; and then pouring water.

Even today almost all of these can be experimented fruitfully.

6. Preservation of Seeds

According to *BS* seeds of trees and plants in general should be preserved in the following way: Water several times the seed of any tree or plant with the liquid portion of the fruit of aṅkola tree or with the oil of śleṣmātaka (Cordia mixa) tree. Only after this the seed should be sown.[48]

Regarding the śleṣmātaka seed, he says: Remove the shell of the seeds and then soak them in aṅkola fruit juice and dry them in shade. Do the same seven times. Then the seeds should be smeared with buffalo's dung and kept in buffalo's dung itself.[49]

More or less in this same way, *SST* also says about preservation of seeds. Well-matured seeds of fruits of the season should be sprinkled with milk and clarified butter, kept for five days in this condition and fumigated with frankincense.[50] Another method: Besmear the seeds sprinkled with milk, with powders of bṛhatī (Solanum xanthocarpum) and sesamum mixed with ghee; dry them and besmear them again with cowdung; then fumigate them with fat of some animal.[51] Yet another way: Besmear the seeds with cowdung after having sprinkled with milk; dry them and besmear them again many times with viḍaṅga powders mixed with honey.[52]

7. Pests and Disease Management

BS deals mainly with exogenous disease of trees. Pale-whiteness instead of greenness of leaves, scanty/sickly sprouting of leaves, fading of branches and leaking of saps from stems are the symptoms of diseases of trees and plants caused by extreme cold,wind and heat.[53] Treatment to this disease can be done as follows: First the faded branch of the tree should be cut away at the point where the illness is not spread. On that part, apply the ointment mixing viḍaṅga, ghee and silt. Then sprinkle milk and water.[54] Utpala quotes four verses from Kaśyapa in the commentary on this verse which hold the same view with some details. Diseases caused by branches, leaves and shade and those of absence of leaves and fruits and waning lustre of leaves are mentioned. They are due to cold, heat, rain and wind and by roots intertwined. Sometimes elephants are also responsible for tree disease. They rub their temples against trees.[55]

Dropping out of fruits prematurely is another plant disease mentioned in *BS*. Treatment for this is to sprinkle a liquid mixture consisting of water, milk, horse gram, black gram, green gram, sesamum and barley which is to be boiled first and then cooled.[56]

SST deals with the treatment of plants according to the way of Āyurveda. He points out that trees, like men, get diseases through the affections of vāta (wind), pitta (bile) and kapha (phlegm) - three pathological humours. So, in his view, one should diagnose the diseases through their symptoms and cure them radically.[57] SST recommends cutting away of the affected parts in the cases when a tree is consumed by insects, burnout by fire, broken by storm, and struck by thunderbolt. But in the case of diseases, he prescribes different treatment.[58] He presents the characteristics of trees of windy humour as follows: They are tall, thin, short, sleeping or partly conscious; and they do not bear flowers and fruits.[59] Then he describes trees of bilious temper: They cannot bear the rays of sun, are of yellow colour, and shed their branches over and over again, and bear premature fruits[60]. Then come trees of phlegmatic temper: They have their branches and

leaves very glossy, flowers and fruits well shaped and of good appearance,trunks symmetrical, and all parts covered with creepers.[61] *SST* continues: Substance of pungent, bitter or caustic tastes are destructive of the windy humour of trees; those having bitter, hot, salty and acid juice are destructive of the bile, and those with graceful, sweet, acid or salty juice are destructive of the phlegm.[62] Following this *SST* describes how can be cured these tempers: The affections of windy humour are alleviated through the application of graceful things like clarified butter mixed with flesh juice, the affection through the bile is alleviated through the application of things that are cold and graceful mixed with water; and the affection through phelgm is modified through the application of acid things mixed with hot water, or through pungent and bitter things.[63] Then *SST* enumerates diseases of plants due to windy humour and prescribes the medicine thereof: Rudeness of appearance, tubercles (nodules over the body) both of large and small size are due to windy humour. The same may be overcome by the application of lodhra (Symplocos paniculata) flower, cowdung, fats and kuṇapa water.[64] It continues: It should be understood that worms at the roots of plants affected with tubercles, of plants having paleness of buds and flowers, should be rooted out with care. Then application should be made to the trunk of the mixture of fresh urine of cows, clarified butter, viḍaṅga, mustard and sesamum; fumigate them and then pour milk and water.[65] *SST* recommends for the destruction of all kinds of worms, the application to the roots of trees the barks of Honge, Cassia fistula, Bead tree, saptaparṇa (Alstonia scholaris) pasted in the urine of cows together with viḍaṅga and nutgrass.[66] The author ponits out that the bodies of trees burnt with fire will bear leaves when besmeared with lotus bulb pasted with kuṇapa water and milk.[67] *SST* maintains that one should besmear the branch of a tree broken by wind with the barks of Peepal, arka (Calotropis gigantea) and Ficus glomerata pasted in ghee, honey and bees wax mixed with milk; should set it as before, and tie it to a post nearby, and apply finely powdered earth to the fractured part. Sprinkle it with milk over and over again; water at its root; then the tree will come back to its former position.[68]

SST prescribes the treatment of trees struck by lightning thus: Mustā (Cyperus rotundus), uśīra, madhuka, greengram, blackgram, barley and sesamum pastes with milk and water - this is to be applied to the roots of such a tree.[69] It recommends kuṇapa water and milk again and again for removing dotage of trees through repeated production of fruits and flowers.[70] When the branches of a tree become dry owing to excess or want of application of water, a boiled mixture of viḍaṅga, clarified butter and milk is prescribed to be sprinkled for a week.[71] When a tree suffers from incapacity to digest water, it is always pale, devoid of barks and leaves, full of ants and the smell of fish. Treatment for this is recommended as follows:

Strike at the root of such a tree to draw the poisonous sap out of the trunk, apply to the affected place a paste of honey, Viḍaṅga powder and sesamum and cover it with water and milk. The atrophy of a tree is radically cured, if it is besmeared with the above paste, after it is sprinkled with sugar and sesamum mixed with milk and water and then fumigated.[72] Lastly, *SST* prescribed the treatment for exudation of trees. To stop this, it is recommended that the barks of priyaṅgu, vara, karkarī, vetasa and nīrmarutu pasted with and boiled in milk should be applied to the tree.[73]

In comparison to *BS*, in many aspects of science of plant pathology and allied subjects, *SST* stands far better, especially in prescription and preparation of fertilizers and treatment of plants.The reason for this is not merely that *SST* is posterior to *BS*. While the author of *BS* is primarily an astronomer cum astrologer and it is as a part of giving an encyclopaedic knowledge of each and every subject to an astronomy-astrology practitioner that he deals with plant pathology too in his work, Śārṅgadhara is in the main an authority of medicine and it is as a part of the vast subject that he treats the present topic too. Any how, contributions of these two authors to the thoughts of vṛkṣāyurveda are remarkabale.

The above observations make it reveal that literary materials connected with treatment of plant life especially with biodiversity and

conservation in ancient and medieval Sanskrit works are immense and most of them are relevant even today.

References

1. *Tantrasārasaṅgraha* by Nārāyaṇa with *Mantravimarśinī* commentary by Svarṇagrāma Vāsudeva, Part I, Calicut University Sanskrit Series No. 15, 2002, p.22.
2. There is slight change in the names of certain trees according to some. Vide A. Achyuthan & Balagopal T. S. Prabhu, *An Engineering Commentary on Manuṣyālayacandrikā*, Appendix II, p.317.
3. Sanskrit, Malayalam; Sanskrit, Malayalam; Botanical name, respectively.
4. फलकुसुमसंप्रवृद्धिं
वनस्पतीनां विलोक्य विज्ञेयम्।
सुलभत्वं द्रव्यानां
निष्पत्तिश्चापि सस्यानाम् ।। (*Bṛhatsamhitā*, *BS*, 29.1)
5. प्रान्तच्छायाविनिर्मुक्ता
न मनोज्ञा जलाशयाः।
यस्मादतो जलप्रान्ते-
ष्वारामान् विनिवेशयेत् ।। (*BS*, 55.1)
6. बहुभिर्बत किं जातैः पुत्रैर्धर्मार्थवर्जितैः।
वरमेकः पथि तरुर्यत्र विश्रमते जनः।।
(Śārṅgadharasamhitā, Tarumahimā, *SST*, 4)
7. दशकूपसमा वापी दशवापीसमो ह्रदः।
दशह्रदसमः पुत्रो दशपुत्रसमो द्रुमः।। (*ibid*, 5)
8. मृद्वी भूः सर्ववृक्षाणां हिता तस्यां तिलान् वपेत्।
पुष्पितांस्तांश्च मृद्नीयात् कर्मैतत् प्रथमं भुवः ।। (*BS*, 55.2)
9. सम्यक् कृष्टे समे क्षेत्रे माषानुप्त्वा तिलांस्तथा।
सुनिष्पन्नानपनयेत् तत्र बीजोप्तिरिष्यते।। (*SST*, 50)
10. अरिष्टाशोकपुन्नागशिरीषाः सप्रियङ्गवः।
मङ्गल्याः पूर्वमारामे रोपणीया गृहेषु वा।। (*BS*, 55.3)
शिरीषोदुम्बराः श्रेष्ठाः पारिजातकमेव च।।

एते वृक्षाः शुभाः ज्ञेयाः प्रथमं तांश्च रोपयेत्।
देवालये तथोद्याने गृहेषूपवनेषु च।।
(Kaśyapa, quoted by Utpala in the commentary on the above verse)

11. गृहस्य पूर्वदिग्भागे न्यग्रोधः सर्वकामिकः।
उदुम्बरस्तथा याम्ये वारुण्यां पिप्पलः शुभः।।
प्लक्षश्चोत्तरतो धन्यो विपरीतांस्तु वर्जयेत्।। (*SST*, 24)
12. वर्जयेत् पूर्वतोऽश्वत्थं प्लक्षं दक्षिणतो गृहात्।
पश्चिमे चैव न्यग्रोधं तथोदुम्बरमुत्तरे ।। (*SST*, 25)
13. सर्वेषां वृक्षजातीनां छाया वर्ज्या गृहे सदा।
अपि सौवर्णकं वृक्षं गृहद्वारे न रोपयेत्।। (*SST*, 27)
14. न कुर्युर्याम्यनैरृत्याग्नेयेष्वपि हि वाटिकाम्।।
अन्यथा कलहोद्वेगौ कष्टं वा लभते भृशम्।। (*SST*, 32)
15. उत्तमं विंशतिर्हस्ता मध्यमं षोडशान्तरम्।
स्थानात् स्थानान्तरं कार्यं वृक्षाणां द्वादशान्तरम्।। (*BS*, 55.12)
16. अभ्यासजातास्तरवः संस्पृशन्तः परस्परम्।
मिश्रैर्मूलैश्च न फलं सम्यग् यच्छन्ति पीडिताः।। (*BS*, 55.13)
17. मण्डपनन्द्यावर्तस्वस्तिकचतुरश्रसर्वतोभद्रैः।
वीथीनिकुञ्जपुञ्जकविन्यासैः पादपा रोप्याः।। (*SST*, 64)
18. द्विचतुस्त्रिभिरन्तरितान् क्रमश-
स्तृणपादपगुल्मभृतश्च वपेत्।। (*SST*, 65cd)
19. सान्द्ररोपणमवृद्धिकारणं
वातभीतिरतिदूररोपणात्। (*SST*, 66ab)
20. अन्ये चोत्तममध्यमाधमशिफा रोप्याः स्ववर्गैः समं
कृत्वा चान्तरकं यथायथममी पत्रैरुपर्यस्पृशः। (*SST*, 70cd)
21. सर्वस्यापि नवोप्तस्य सायंप्रातर्निषेचनम्।
शीतातपसमीरेभ्यो रक्षेच्च सुविधानतः।। (*SST*, 71)
22. हेमन्ते शिशिरे देयं जलं चैकान्तरे दिने।
वसन्ते प्रत्यहं ग्रीष्मे सायंप्रातर्निषेचनम्।। (*SST*, 72)
23. वर्षासु च शरत्काले यदा वृष्टिर्न दृश्यते।
तदा देयं जलं तज्ज्ञैरालवाले महीरुहाम्।। (*SST*, 73)
24. वारिणा यावता यस्य मूले सौहित्यमिष्यते।

तावत्तस्य तरोर्देयं किं घटार्थविवक्षया।। (*SST*, 74)

25. आलवाले स्थितं तोयं शोषं न भजते यदा।
अजीर्णं तद्विजानीयान्न देयं तादृशे जलम्।। (*SST*, 75)

26. समीपजातं यत्नेन तृणगुल्मलतादिकम्।
स्फोटनीयं विधिज्ञेन द्रुमाणां वृद्धिमिच्छता।। (*SST*, 76)

27. नीहाराच्चण्डवाताच्च धूमाद् वैश्वानरादपि।
जालकारात् प्रयत्नेन रक्षणीया महीरुहः।। (*SST*, 77)

28. वृक्षाः कार्या युता वृत्या सा चापि परिखायुता।। (*SST*, 78cd)

29. विद्युदाहतवृक्षस्य भूमिमादाय सर्वतः।
रक्षार्थे विकिरेदेषां तया न हिमबाधनम्।
दीप्तोऽप्यग्निः शमं याति वज्रदग्धद्रुभस्मना।। (*SST*, 79)

30. सितशाल्योदनं दध्ना सैन्धवेन युतं वने।
क्षेपणीयं च परितो गराणां वृष्टिवारणम्।। (*SST*, 80)

31. घृतोशीरतिलक्षौद्रविडङ्गक्षीरगोमयैः।
आमूलस्कन्धलिप्तानां सङ्क्रामणविरोपणम्।। (*BS*,55.7)

32. अजातशाखान् शिशिरे जातशाखान् हिमागमे।
वर्षागमे च सुस्कन्धान् यथादिक्स्थान् प्ररोपयेत्।। (*BS*, 55.6)

33. बीजाधानीं तृणास्तीर्णां कृत्वा सिञ्चेत् पयोऽम्बुना।
जाताङ्कुरां च सलिलैर्निस्तृणं शोषमानयेत्।। (*SST*, 56)

34. हस्तप्रमाणं पयसा सुसिक्तान्
सङ्क्रामयेन्मूलवहः समृत्कान्।
सर्पिर्मधूशीरविडङ्गलिप्तान्
बिले निदध्याच्च करीषयुक्ते।। (*SST*, 59)

35. अवालुकश्ळक्ष्णमृदा पुरीते गर्तशोधनम्।
कोदण्डार्धमिते खाते जलसिक्ते वपेत् तरुम्।
कदळीक्षीरिणौ रोप्यौ मूले दत्वा तु गोमयम्।। (*SST*, 60)

36. रम्भायाः सुपरिणतैः फलैर्विलिप्तां
संशुष्कां भुवि निहितां पलालरज्जुम्।
शुद्धायामुपरि तृणेन गाढगुप्ता-
मासिञ्चेदबहुजलैर्बहून्यहानि।। (*SST*, 61)

37. सा रज्जुस्तदनु तमालनीलभासो
बिभ्राणामरुणरुचोऽङ्कुरान् प्रसूते ।

भूयस्तानुपचितपत्रकाण्डमूला-
नारोप्य प्रथितविधानतो निषिञ्चेत्।। (*SST*, 62)

38. वासराणि दश दुग्धभावितं
बीजमाज्ययुतहस्तयोजितम्।
गोमयेन बहुशो विरूक्षितं
क्रौडमार्गपिशितैश्च धूपितम्।।
मांससूकरवसासमन्वितं
रोपितं च परिकर्मितावनौ।
क्षीरसंयुतजलावसेचितं
जायते कुसुमयुक्तमेव तत्।। (*BS*, 55.19-20)

39. तिन्दिडीत्यपि करोति वल्लरीं
व्रीहिमाषतिलचूर्णसक्तुभिः।
पूतिमांससहितैश्च सेचिता
धूपिता च सततं हरिद्रया।। (*BS*, 55.19-21)

40. कपित्थवल्लीकरणाय मूला-
न्यास्फोटधात्रीधववासिकानाम्।
पलाशिनीवेतससूर्यवल्ली-
श्यामातिमुक्तैः सहिताष्टमुली।।
क्षीरे शृते चाप्यनया सुशीते
तालाशतं स्थाप्य कपित्थबीजम्।
दिने दिने शोषितमर्कपादै-
र्मासं विधिस्त्वेष ततोऽधिरोप्यम्।।
हस्तायतं तद् द्विगुणं गभीरं
खात्वावटं प्रोक्तजलावपूर्णम्।
शुष्कं प्रदग्धं मधुसर्पिषा तत्
प्रलेपयेद् भस्मसमन्वितेन।।
चूर्णीकृतैर्माषतिलैर्यवैश्च
प्रपूरयेन्मृत्तिकयान्तरस्थैः।
मत्स्यामिस्यस्सहितं च हन्याद्
यावद्घनत्वं समुपागतं तत्।।
उप्तं च बीजं चतुरङ्गुलाधो
मत्स्याम्भसा मांसजलैश्च सिक्तम्।
वल्लीभवत्याशु शुभप्रवाळा

विस्मापनी मण्डपमावृणोति।। (*BS, 55.22-26*)

41. ध्रुवमृदुमूलविशाखा
गुरुभं श्रवणस्तथाश्विनी हस्तः।
उक्तानि दिव्यदृग्भिः
पादपसंरोपणे भानि।। (*BS, 55.31*)

42. पनसाशोककदळीजम्बूलकुचदाडिमाः।
द्राक्षा पालीवतश्चैव बीजपूरातिमुक्तकाः।।
एते द्रुमाः काण्डरोप्या गोमयेन प्रलेपिताः। (*BS, 55.4, 5a*)

43. ताम्बूली सिन्धुवारश्च तगराद्याश्च काण्डजाः।
पाटलादाडिमीप्ळक्षकरवीरवटादयः।
मल्लिकोदुम्बराः कुन्दो बीजकाण्डोद्भवा मताः।। (*BS, 47cd,48*)

44. मूलोच्छेदेऽथवा स्कन्धे रोपणीयाः परं ततः। (*BS, 55. 5b*)

45. ततोऽनन्तरं परं प्रकृष्टं मूलोच्छेदं कृत्वा तस्य छिन्नमूलस्योपरि विजातीयो वृक्षो रोपणीयः। अथवा स्कन्धादर्धाद् अन्यवृक्षं छित्वा तस्य स्कन्धमुत्कीर्य विजातीयो वृक्षो रोपणीयः।

46. आविकाजशकृच्चूर्णस्याढके द्वे तिलाढकम्।
सक्तुप्रस्थो जलद्रोणो गोमांसतुलया सह।।
सप्तरात्रोषितैरेतैः सेकः कार्यो वनस्पतेः।
वल्लीगुल्मलतानां च फलपुष्पाय सर्वदा।।(*BS, 55.17-18*)

47. कुरङ्गकिटिमत्स्यानां मेषच्छागलखड्गिनाम्।
मांसं ग्राह्यं यथालाभं मेदोमज्जावसास्तथा।।
तान् सर्वानेकतः कृत्वा वह्नौ नीरेण पाचयेत्।
सपक्वं हि क्षिपेद् भाण्डे तत्र दुग्धं च निक्षिपेत्।।
चूर्णीकृत्य खलिर्देया तिलानां माक्षिकं तथा।
स्विन्नांश्च सरसान् माषांस्तत्र दद्याद् घृतं तथा।।
उष्णं जलं क्षिपेत् तत्र मात्रा नास्तीह कस्यचित्।
पाक्षिकं स्थापिते भाण्डे कोष्णस्थाने मनीषिणा।
कुणपस्तु भवेदेव तरुणां पुष्टिकारकः।। (*SST, 171-4*)

48. शतशोऽङ्कोलसम्भूतफलकल्केन भावितम्।
एततैलेन वा बीजं श्लेष्मातकफलेन वा।। (*BS, 55.27*)

49. श्लेष्मातकस्य बीजानि निष्कुलीकृत्य भावयेत् प्राज्ञः।
अङ्कोलविज्जलद्भिश्छायायां सप्तकृत्वैवम्।।

माहिषगोमयघृतसान्यस्य करीषे च तानि निक्षिप्य।
करकजलमृद्योगे न्युप्तान्यह्ना फलकराणि।। (*BS, 55.29-30*)

50. अथर्तुपक्वात् फलतो वसोषितान्
विकृष्य बीजं पयसा निषिच्य।
विशोषितं पञ्च दिनानि सर्पिषा
विडङ्गमिश्रेण च धूपयेत् ततः।। (*SST, 51*)

51. क्षीरनिषिक्तं बीजं बृहतीतिलभस्मसर्पिषा लिप्तम्।
गोमयमृदितमथोप्तं सद्यो जायेत धूपितं वसया।। (*SST, 52*)

52. पयसि निषिक्तं बीजं गोमयपरिमर्दितं विशोष्य ततः।
माक्षिकविडङ्गचूर्णैर्बहुशो मृदितं प्रजायेत।। (*SST, 53*)

53. शीतवातातपै रोगो जायते पाण्डुपत्रता।
अवृद्धिश्च प्रवाळानां शाखाशोषो रसस्रुतिः।। (*BS, 55.14*)

54. चिकित्सितमथैतेषां शस्त्रेणादौ विशोधनम्।
विडङ्गघृतपङ्काक्तान् सेचयेत् क्षीरवारिणा।। (*BS, 55.15*)

55. शाखाविटपपत्रैश्च छायया विहिताश्च ये।
येऽपि पर्णफलैर्हीना रूक्षाः पत्रैश्च पाण्डुरैः।।
शीतोष्णवर्षवाताद्यैर्मूलैर्व्यामिश्रितैरपि।
शाखिनां तु भवेद् रोगो द्विपानां लेखनेन च।।
चिकित्सितेषु कर्तव्या ये च भूयः पुनर्नवः।
शोधयेत् प्रथमं शस्त्रैः प्रलेपं दापयेत् ततः।।
कर्दमेन विडङ्गैश्च घृतमिश्रैश्च लेपयेत्।
क्षीरतोयेन सेकः स्याद् रोहणं सर्वशाखिनाम्।।
(Quoted from Kaśyapa in the commentary of Utpala)

56. फलनाशे कुलत्थैश्च माषैर्मुद्गैस्तिलैर्यवैः।
शृतशीतपयःसेकः पलपुष्पसमृद्धये।। (*BS, 55.16*)

57. नराणामपि वृक्षाणां वातपित्तकफाद् गदः।
सम्भवन्ति निरुप्यातः कुर्यात् तद्दोषनाशनम्।। (*SST, 175*)

58. कीटजग्धेऽग्निसंप्लुष्टे वातभग्नेऽशनिक्षते।
वृक्षे छेदोपचारादिपीडिते च पृथक् क्रिया।। (*SST, 176*)

59. कृशदीर्घो लघुरूक्षो निद्राहीनोऽल्पचेतनः।
न धत्ते फलपुष्पाणि वातप्रकृतिकस्तरुः।। (*SST, 177*)

60. अतापसहनः पाण्डुः शाखाहीनो मुहुर्यदि।

अकालफलपाकी स्याच्छाखी पित्तात्मकः स्मृतः।। (*SST, 178*)

61. स्निधशाखादलः शाखी सम्यक् पुष्पफलोज्जलः।
लतापरीतगात्रस्तु कफवान् परिमण्डलः।। (*SST, 179*)

62. कटुतिक्तकषायरसैः पवनः पित्तं कटूष्णलवणाम्लैः।
स्निग्धमधुराम्ळलवणैः श्ळेष्मा कोपं प्रयाति तरोः। (*SST, 180*)

63. सुस्निग्धैः पिशितरसैः प्रयाति वातः
सुस्निग्धैर्मधुरहिमैर्जलैश्च पित्तम्।
कट्वम्ळैरहिमजलैः कषायरुक्षैः
श्ळेष्मापि क्रमविहितैः प्रयाति नाशम्।। (*SST, 181*)

64. रौक्षं ग्रन्थिः कुटिलता वाताद् वृक्षस्य जायते।
गोविड्लोध्रवसाकुणपजलैस्तज्जयो भवेत्।। (*SST, 182*)

65. दोषैर्यस्य विना प्रवाळकुसुमम्ळानिर्विरुढं वपे-
र्मूले तस्य तरोर्भवन्ति क्रिमयो यत्नाच्च तानुद्धरेत्।
गोमूत्राज्यविडङ्गसर्षपतिलैर्लिप्तः प्रणष्टैस्ततः
सिक्तः क्षीरजलैरुदेति सहसा धूपैश्च धूपायितः।। (*SST, 183*)

66. करञ्जारग्वधारिष्टसप्तपर्णत्वचा कृतः।
उपचारः क्रिमिहरो मूत्रमुस्ताविडङ्गवान्।। (*SST, 184*)

67. कुणपजलपयोनिषिक्तमूलः
सरसिजकाण्डविलिप्तसर्वगात्रः।
तरुरनलहतो बिभर्ति भूयो
मरतकरङ्गहरिन्ति पल्लवानि।। (*SST, 185*)

68. प्ळक्षार्कोदुम्बरत्वग्घृतमधुमधुरोच्छिष्टदुग्धैर्विलिप्तः
स्तम्भैरुत्तम्भ्य रज्ज्वा परिकलितवपुः पूरितः प्ळक्षमुद्भिः।
सिक्तः क्षीरेण भूयो जलभरिततलश्चण्डवातादिभग्नः
स्वस्थो भूत्वाङ्घ्रिपायी कुसुमफलभराण्यातनोति प्रकामम्।। (*SST, 186*)

69. वृक्षस्याशनिदग्धस्य जीवनं शृणु भेषजम्।
घनोशीरमधूकैश्च मुद्गमाषान् यवांस्तिलान्।।
पिष्ट्वा क्षीराबुसंयुक्तैः सेचयेत् तमभीक्ष्णशः।
स सेकाप्यायितः शीघ्रं प्रकृतिस्थो भविष्यति।। (*SST, 187-8*)

70. जनयित्वा फलकुसुमं यः पुनरुपयाति वन्ध्यतां शाखी।
सक्षीरैः कुणपजलैर्भूयः सिक्तः फलत्येव।। (*SST, 187-9*)

71. असेकतोऽत्यन्तनिषेकतश्च

शाखाविशेषान् फलिनो निरुप्य।
सप्ताहमात्रं शृतमेव सर्पि-
र्विडङ्गदुग्धाम्बु निषेचनीयम्।। (*SST, 190*)

72. तन्मूलशूलं परशुप्रहारै-
र्विस्रावितं दोषरसं निहत्य।
क्षौद्राज्यजन्तुघ्नतिलैः प्रलिप्तं
मृत्पूरितं दुग्धजलैर्निषिञ्चेत्।।
शर्करातिलगोक्षीरवारिसेकात् तथा तरोः।
शोषः संयाति वृक्षस्य लेपाद् धूपोपचारतः।। (*SST, 192-3*)

73. प्रियङ्गुवरकर्करीवेतसार्जुनवल्कलैः।
क्षीरसिद्धैर्विलिप्तानां सर्वः संयाति शाखिनाम् (*SST, 194*)



Plant Science in Śārṅgadharasamhitā

C. Narayanan

There are ample evidence in the ancient Indian texts to show that the treatment of plants had then been considered as a separate branch of knowledge. And what substantiates this argument is the classification of the various stages in the growth of a plant and analysis of its methods such as sowing, nourishing, transplanting, grafting and so on, in those texts. This implies that the science of agriculture was already known to Indians and also that it is not a new branch of knowledge introduced by the West, though, there may be difference of opinion on whether the term Science can be used with it in the strict sense of modern technology and methodology. Thanks to the Indian research Institute, Culcutta, for publishing the ancient and medieval texts pertaining to 'Indian positive sciences'. For, hadn't they taken interest and initiative, a world of wisdom would have gone to oblivion. The *Arthaśāstra*[1] refers to the appointment of officers with knowledge of agriculture. The Indian Institute's first publication appeared in Sanskrit is a treatise on Arbori-horticulture, *Upavanavinoda*[2]. The next was Śārṅgadhara's encyclopedic work called Śārṅgadharasamhitā.[3] The renowned scholar Brajendranath Seal, in his forword to this book, pointed out that "mere religion and theology was not the pre-occupation of the Hindu mind" and that the subject of Vṛkṣāyurveda became prevalent as a distinct branch of positive knowledge as early as the *Arthaśāstra* of Kuṭilya expressly refering to it. This paper is on the Plant Science in *Śārṅgadharasamhitā*[4]

The matter pertaining to Vṛkṣāyurveda has been collected from

numerous textbooks of Vṛkṣāyurveda as the text itself includes a reference: nānāvṛkṣāyurveda śāstrebhyaḥ[5]. This makes it clear that there were many works in Sanskrit bearing on this subject. Unfortunately, most of the texts are not available now. The Vṛkṣāyurveda chapters in *Śārṅgadharasamhitā* contain chapters glorifying trees. Trees glorified[6] are basil plants, bilva tree, aśvattha, amalaka, banian tree, nimba, palāśa, amara, śirīṣa, udumbara, madhūka, kṣīraka, kadali, drākṣā, priyāla, panasa, picumanda, nyagrodha, tamerind, and kapittha.

It recommends planting of a tree on way side where people may rest under its shadows, than to have many sons born who are devoid of wealth and virtue.[6] The plants desirable and non-desirable in the residences are also mentioned. Plants desirable in residences are banian tree, udumbara, pippala, plakṣa, badarī, kadalī, dāḍima and bījapūraka.[7] The following verse is noticeable:

दशकूपसमा वापी दशवापीसमो ह्रदः ।

दशह्रदसमः पुत्रो दशपुत्रसमो द्रुमः ।

Sowing

The *Śārṅgadharasamhitā* contains details regarding sowing of seeds. One should sow pulses and sesamum on level ground[8], sprinkling of milk and clarified butter over them, keep five days in this condition and then fumigate them with frankincense. They sprout in a single night[9]. Another method of growing seeds soon is also mentioned. According to earlier texts process of planting of trees in certain constellations is also[10] mentioned[11]. One should plant trees 10 cubits on the lower level and 20 cubits on the higher level.[12] Trees thickly sown hinder their growth and if sparsely sown, they are in danger of falling down.[13]

Transplanting

Transplanting of trees is discussed in *Śārṅgadharasamhitā*. Seeds are transplanted when they grow. When a sprout planted after being sprinkled with milk grown one cubit in length, one should dig it out together with the mud attached thereto and then apply to it roots of uśīra, viḍaṅga and ghee pasted together and then replant it in a pit

together with cowdung[14]. Trees in the garden are arranged in svastika, caturaśra, sarvatobhadra, vidhi and in nikuñja and in clusters.[15] Planting trees thickly hinders their growth and if planted very sparsely, they are in danger of falling down, even in mild winds; hence for lean plants, in laying out a garden, planting after the method described above is wise.[16]

Śārṅgadharasamhitā contains directions of destroying worms and insects that destroy the crops. All kinds of worms are destroyed by applying Karañja, Āragvadha, Ariṣṭa and Saptaparṇa pasted in the urine of cows together with Viḍaṅga and Mustā.[17] Plants and trees burnt by fire are besmeared with lotus bulb pasted with kuṇapa water and milk, produce green leaves.[18]

Grafting

Earlier methods of grafting is seen in *Śārṅgadharasamhitā* wherein, when the trees are broken by wind, trees pasted in ghee, honey and bees wax mixed with milk and fixed by tying to a post and applying powdered earth to the fractured part. If it is sprinkled with milk over and over again and watered at the root, the tree becomes sound and produces abundant fruits and flowers.[19]

Soil Testing

Testing soil in ancient India is seen described in *Śārṅgadhara samhitā*. The selection of soil is done.[20] Soils having black, pale, blue, yellow and white colours are associated with sweet, acid, salty, sour, bitter and pungent tastes. Hence soils are classified as jāṅgala (barren) anūpa (moist) and sāmānya (ordinary). The soil that is uneven, barren and stony are not fit for growth of trees. Eventhough testing laboratories as in nowadays are not mentioned, earlier methods of soil testing and ground selection for cultivation were scientific. Examination of soil for digging well is also mentioned in detail.

Watering

In the gardens deep wells, paved with all suitable stone is used for watering the garden. Selection of places for digging well is explained in detail. Modern methods of selecting places for digging wells are to be compared with earlier methods. The water below the ground is

tasty[21]. Where the earth is yellowish, the water below the surface is caustic. Where the earth's colour is pale, the surface is salty.[22] Where the earth is of blue colour, the water is sweet[23]. Watering of plants is recommended once in the morning and afternoon. When the water in the ditches are not dried up, the trees may cause indigestion. [24]

Treatment of Plants

Śārṅgadharasamhitā considers plants-treatment similar to that of human beings through Āyurveda norms. Accordingly the text tells that trees get diseases like men do, due to the affections of vāta (wind) pitta (bile) and kapha (plegm), the three pathological humours. One should diagnose the diseases through their symptoms and cure them radically. Tall, thin, stout, sleeping or conscious trees are of windy humor (vāta) and hence they do not bear fruit.[25] Plants of bilious temper (pitta) shed their branches over and over again and bear premature fruits.[26] Plants of phlegmatic temper (kapha) have their branches and leaves very glossy, flower and fruits well shaped and of good appearance, trunks symmetrical and all parts covered with creepers.[27]

Trees with windy humour taste bitter or caustic and destructive and those having bitter, hot, salty and acid juice are destructive of the bile and those with graceful sweet, acid and salty juice are destructive of the plegm.[28]

The windy humour is alleviated through the application of graceful things that are cold and graceful mixed with water, and the affection through plegm is modified through the application of acid things mixed with hot water, or through pungent and bitter things.[29] Windy humour is removed also by application of lodhra flower, cowdung and fats of kuṇapa water.[30]

Gardening

Horticulture in ancient India was a well developed science. *Śārṅgadharasamhitā* tells that the art of enjoyment of gardening was well established during the early age of kings and queens[31]. The pleasure-seeking soverigns constructed houses with extensive gardens,

spacious gardens containing large pools of water with lovely lotuses and bees. The details of gardening are present in *Śārṅgadharasamhitā* wherein the plots are selected by farmers in cultivating lands. Constructin of garden with blooming flowers and proceeded by breezes and bristling with restless black bees are narrated[32]. Beautiful, artificial caves adorned by branches of trees and creepers are constructed[33]. For fear of serpents one should grow peacocks in the garden[34]. Ponds, artificial lakes with pleasure boats are constructed.

Fertilizers

Śārṅgadharasamhitā refers to different fertilizers for each plant. It prescribes a kind of nourishing solution called kuṇapajala which is similar to modern compost preparation.

Nourishment of Plants

The nourishment of plants as framed by old sages who are also cultivators are to be studied in detail. In addition to watering, certain other steps are mentioned. Powder of Barly helps coconut grow fast, mango trees fruit early if they are watered with decoction of milk, leaves of mango trees, Aśvattha, Vaṭa, Plakṣa and Yajñadruma together with the fat of deer, boar, jackal, elephant, horse etc[35]. For the nourishment of plants kuṇapajala is prepared [36]. One should root out the tubercles, worms and other insects by pouring fresh urine of cows, clarified butter, viḍaṅga, mustard and sesamum applied together to the trunk, then fumigated and watered with milk and water.[37]

Botanical Marvels

Śārṅgadharasamhitā gives a detailed account of botanical marvels. Trees bearing scentless flowers, if treated with earth soil scented through association with fragrant flowers and sprinkle it with decoction of the dhava and khadira barks, and besmears it with sandal dust and then fumigates with clarified butter it bears fragrant flowers[38]. A cotton tree is to produce fibers as red as burning fire if one applies barly, sesamum, niśā and powdered bark of palāśa tree to it[39]. If the fiber is to be yellow as the feather of śuka bird it can be done by adding barks of śālmalī, turmeric, indigo, triphala, kuśa and rock salt powdered and mixed

with wine and applied to roots[40]. Fibers are made blue if mañjiṣṭhā, tila, yava, pītasāra, leaves of jivanī, powdered manaśśilā mineral be pasted together with the milk of cow or goat sprayed to the root[41]. Flowers and froots are grown in out season times as well, if cut stem of tree be besmeared with boiled sugarcane juice, and applied to that[42].

In order to increase the size of fruit, one should thrust a rod in the stool of an ass and then heat it on fire and then pierce it slashingly into the trunk of plantain tree[43]. To make the fruits devoid of seeds, yaṣṭimadhu, sugar, kuṣṭha, flower of madhuka be pasted together and applied to the root[44].

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7. *Ibid.*
8. *Ibid.*50.
9. *Ibid.*52.
10. *Ibid.*53.
11. *Ibid.*58.
12. *Ibid.*65.
13. *Ibid.*66
14. *Ibid.*59.
15. *Ibid.*64.
16. *Ibid.*66.
17. *Ibid.*184.
18. *Ibid.*185.
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20. *Ibid*,34-36.
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22. *Ibid*,146
23. *Ibid*,75.
31. *Ibid*.1.
32. *Ibid*.83.
33. *Ibid*.85.
34. *Ibid*.86.
35. *Ibid* 150
36. *Ibid* 171-174.
37. *Ibid*, 183.
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43. *Ibid*, 221.
44. *Ibid*, 202, 217



On Indian Chemistry

M. P. Kannan

The word 'science' literally means knowledge and when this knowledge is put to practical use it becomes 'technology'. As we know the basic human instinct is to find explanation for the phenomena he sees around. Thus, he began asking basic questions about the world around him: What are those that shine in the night sky? Why sun is hot and moon cold ? What is night and why is it different from day ? What is fire and why does it burn? What is rain ? Why does a tree fall ? What are a human and an animal and how are they different ? What is life ? What is death? The questions 'Why?' and 'What?' reverberated in his mind every now and then keeping him searching for finding an explanation. This led to a rich accumulation of information and knowledge.The history of ancient Indian science traces back to the prehistoric period. The Indian science grew through the Vedic period (1500 BC - 1000 BC) and got codified in four Vedas - *Ṛg, Yajus, Sāma* and *Atharva*. The post-Vedic period (600 BC - 800 AD) is regarded as the golden period of Indian science, when it flourished the most. Various schools of thought, such as Sāṅkhya, Nyāya and Vaiśeṣika, emerged during this period. *Arthaśāstra* of Kauṭilya (300 BC), Āyurvedic texts like *Carakasamhitā* and *Suśrutasamhitā* (100 BC), *Bṛhatsamhitā* of Varāhamihira (600 AD), etc, were some of the notable works of this period. The wealth of knowledge lying hidden in these works should have greatly helped to give a strong foundation to modern science. However, it seems that most of India's scientific developments remained

isolated on this subcontinent and did not much affect the development of science in the rest of the world, because Indian science is not found properly quoted in the history of science.

A. Indian Chemistry

a. Metals & Metallurgy

The use of metals and their production (metallurgy) has been one of India's most ancient sciences, and probably this marks the beginning of Indian chemistry. Iron was part of the Vedic culture dating back to 1500 BC. Kauṭilya's *Arthaśāstra*, which is regarded as the store house of knowledge, includes references about mines and factories, about the origin of the ores of Au, Cu, Ag, Pb, Fe, etc., and the methods of finding their sources. The first batch of Zn was reported to be made in India around 50 BC at Zawar in Rajasthan. Indian metallurgy was far ahead of time. The Qutab minar, which weighs about 10 tons and is about 1500 years old, yet remaining totally rust-free, stands testimony to the enviable skill of Indian metal workers and the advancement of metallurgy in India.

b. Other Compounds

Chemistry, known as rasāyana śāstra, was initially documented as a part of the Indian medical treatise *Carakasamhitā*. Ancient Indians knew how to prepare alkalis, acids (H_2SO_4, HNO_3), the oxides (of Au, Cu, Fe, Pb, Sn, Zn), sulphates (of Cu, Zn, Fe), the carbonates (of Pb, Fe), chlorides and oxychlorides. Some of these chemicals were used for treating leprosy, ring worm, etc. Ancient Indian chemists knew about gunpowder, whose invention, however, is traditionally ascribed to Chinese.

According to one interpretation (Dey), the weapons mentioned in Indian epics *Rāmāyaṇa* and *Mahābhārata* were actually products of chemistry, the mantras the gurus gave to their pupils were nothing but chemistry, and the arrows were probably coated with certain chemicals.

Suśrutasamhitā describes the preparation and use of alkalies. Three

types of alkalies were mentioned - mṛdu, tīkṣṇa and madhyama. Alkalies were used externally for skin diseases like tumors, leprosy, piles, etc., and internally for indigestion, urinary deposits (stones), etc.

Bṛhatsamhitā refers to mordants such as alum used for fixing dyes on textiles. It mentions about cosmetics, perfumes, hair dyes, cements, etc.

c. Paramāṇuvāda or Atomic Theory

The fundamental priciple used in the practice of chemistry is the atomic theory. It was Democritus (Greece - born about 470 BC) who proposed atomism first. He speculated that the world and everything in it, including human beings, was composed of collections of infinitesimal and invisible particles that were hard and unbreakable. However, this theory lied dormant until its revival by John Dalton in 1808. Here, we note that Kaṇāda, the pioneer of Vaiśeṣika School of thought, postulated atomism as the basis of matter as early as 500 BC.

d. Āyurveda

Ancient India's most potent contribution to the world of science is Āyurveda, the science of healing, which is nothing but applied chemistry. This was developed as early as 900 BC. The use of metals and their compounds, medicinal plants and their uses, herbal rasāyanas, various āyurvedic preparations for rejuvenation, vitalization and cure, etc., have been systematically elaborated in the famous Āyurvedic texts, *Carakasamhitā* and *Suśrutasamhitā*. It was Suśruta, the student of Dhanvantari, who developed surgery.

In ancient times, life's struggle was so severe that no form of social parasitism could be tolerated. To reduce the number of feeders in a family infanticide of girls was practiced and widows were burnt, under the pretext that women are not good breadwinners. Similarly, the aged was felt as social parasite and exiled as ascetic, usually to forest. The solitary life of the ascetic in the forest necessitated an energizer to enable him to search for foodstuff. He gathered medicinal plants primarily to regain youth and to cure other ailments. This marked the beginning of āyurveda.

B. Other Disciplines

India's contributions in the areas of mathematics and astronomy were quite significant. Bhāskara's *Siddhāntaśiromaṇi* (1150 AD) mentions a force of attraction resembling gravity, which Newton discovered centuries later. India's greatest contribution to mathematics came in the form of zero, which revolutionized this branch of science. The decimal system, developed as far back as Vedic period, is another notable contribution of ancient India. The game of chess is yet another proud contribution of India.

C. The Present Status

The pursuit of knowledge in India was thus very strong much before even Vedic times. The great contribution of our ancient Scientists were the fruits of their dedication. What is the present status of Indian Science? Is it encouraging? Or is it disappointing ? We get the answer readily if we look into our University system, whose primary concern is teaching and research. But, Indian University system has been described as the most chaotic system anywhere. As you all know, there is a sort of simmering discontent in the minds of students about the whole business of teaching and research. We can see restless, low motivated students and teachers in the University/Colloge campus. Indian history discloses the fact that something or other is always empty in this country. Before independence it was stomach that was left empty; but now it is the mind. We know only to perform unintelligent mimicry of alien models. It is our sincere wish that it should change.

Great academicians say that the University teacher is the University. Only when the individual teacher is alive, teaching becomes a profession. Then only research flourishes and new horizons of intellectual adventures unfold. I am confident that if we are willing we can take the university system to a new area of light, hope and progress.



The History of Indian Chemistry

K. Muthulekshmi

J.D. Bernal in his monumental work *Science in History* observes that almost every one of the early mechanical achievements of man had already been anticipated by specialized species of animals. But the use of fire is beyond the reach of any animal. It is this almost apparently accidental use of fire that led to its more scientific uses in pottery and metal making; and the tool-using animal was on its way to a scientific humanity. Just as the tool is the basis of physical and mechanical science, so is the fire the basis of chemical science. Cooking of food in fire was the first simple and essentially chemical practice of man. (J.D.Bernal,1954, *Science in History*, Penguin Books, Harmondsworth, p.70)

Introduction

Human endeavour to analyse the composition of the Universe and various objects is as old as civilisation. This led to the study of compositional changes effected by forces external and internal to it, and new compounds were formed by mixing two different substances. The application of this knowledge varies from pottery to medical sciences.

Evidences could be found in literary works of the period and various scientific treatises on alchemy, metallurgy, fireworks, paper works etc. Various works in Sanskrit dealing with other areas of learning also point

to the fact that knowledge about chemistry prevailed in ancient India. Among the 64 arts and sciences enumerated in *Kāmasūtra* of Vātsyāyana there is a mention of suvarṇaratnaparīkṣā (the examination of gold and gems), dhātuvāda *(*chemistry and metallurgy), and maṇirāgākarajñānam (knowledge of mines and quarries, and the colouring of gems and jewels).

In Sanskrit literature, the branch of science which consists of the above said knowledge is called by various names of dhātuvāda, lohaśāstra, rasaśāstra etc. Thus it can be assumed that the scope of this branch of science extends to the different branches of modern chemistry, viz, gemnology, metallurgy, alchemy etc.

This paper attempts to chart out the evidences and mentions found in various texts dating from the prehistoric times in chronological order.

Indus Valley and Harappan Civilisation (from Pre-historic Times to 1500 BC)

Archaeological evidences indicate that chemistry was the basis of many material practices during the Indus valley civilization. Pottery, important among them, has a prominent place in the history of Indian chemistry. The pots were hardened by burning clay in fire; various processes involving minerals like prolonged heating, melting and evaporating were developed during this period. Along with these, the processes of moulding, colouring etc were also developed. A mixture of iron was used in the colouring of pots. Paintings were done with haemarites mixed with manganese. The standardization in the production of pottery is also noteworthy.

Knowledge of fermentation, manufacturing of glass etc also deserves mention.

It is possible that the metals like bronze, copper, lead, silver, gold and electrum were known to the people of Harappan civilization.

Vedic Period (B C 1500 - 600)

Like various other systems of science of the Vedic period, the science of chemistry also developed in relation to the Vedic rites and beliefs. We can see that the manufacturing of various utensils and also the preparation of certain substances (dravya) for Vedic rites were based on chemical knowledge. Many types of metals, their characteristics, and uses etc are referred to in the Vedas, directly and metaphorically.

Ṛgveda mentions metals like gold, copper, silver and bronze. A golden earring and necklace are mentioned thus: *Hiraṇyakarnam maṇigrīvam*[1]

Śuklayajurveda speaks of tin and lead also: *hiraṇyam ca me ayaśca me sīsam ca me trapuśca me śymañ ca me loham ca me.*[2]

Chemists opine that all these metals can only be obtained by complex chemical processes: "Each of these metals has different physical and chemical characteristics and need different types of extraction processes to get them out of their ores. No superfluous knowledge on the ore can give such names for the metals unless they were produced".[3]

Atharvaveda compares the colour of the universal power with that of metals: "His flesh has the colour of śyāma (iron), blood has the colour of loha (copper), totally he has the colour of tin and has the smell of lead".[4]

The technique for metallurgical alloying presented in *Chāndogya Upaniṣad* is like this: "One would join gold with the help of lead, and timber with copper and leather."[5] According to N. Gopalakrishnan, this technique is used till now for reducing the melting point of the metals to be alloyed.[6]

The fact that Ṛgvedic people knew fermentation of drinks is evident from the hymns praising somarasa.There are about 120 hymns praising it. [7]

Such references of Vedic literature point to the chemical

knowledge of that period. Though we find references to the mixing of different metals in the Vedas, we do not get a clear idea of the exact procedure the Vedic people followed for it. One reason may be that the chemists of that period, viz., potters, goldsmiths, black smiths etc, did not record their skills which they learned and passed on hereditarily. Not only that, it can also be assumed that the society of that period had not reached the phase of theorizing practical knowledge.

Post Vedic Period (600 BC - 800 AD)

This period was the flourishing age of Indian Chemistry. Various schools of philosophy, especially Sāṅkhya, Nyāya and Vaiśeṣika, *Arthaśāstra* of Kauṭilya, *Bṛhatsamhitā* of Vārahamihira and Ayurvedic texts like *Carakasamhitā* and *Suśrutasamhitā* provide a lot of evidence regarding the advanced practices of Indian chemistry during this period.

The Sāṅkhya system of philosophy has a unique place in the history of thought because it embodies the earliest cogent and comprehensive account of the process of cosmic evolution, based on the conservation, transformation and dissipation of energy.

The Nyāya and Vaiśeṣika schools (BC 200) formulated the theory of paramāṇuvāda or atomism maintaining that the basic composition of substances was paramāṇu-s or atoms. Paramāṇuvādins probed into the constitution and properties of matter. Kaṇāda, the exponent of Vaiśeṣika philosophy maintains the eternity of atoms. He also explains their existence and aggregation. According to *Tarkasaṅgrahadīpikā*, a text on Nyāya-Vaiśeṣika, the mote which is seen in a sun beam is the smallest perceptible quantity. Being a substance and an effect, it must be composed of what is less than itself, for the component part of a substance that has magnitude must be composed, of what is smaller, and that smaller thing is an atom. It is simple and uncomposed, else the series would be endless.[8] The atom is reckoned to be the one-sixth part of a mote visible in a sunbeam.

Two earthly atoms constitute a double atom of earth and by the

union of three binary atoms, a tertiary atom is produced and by concourse of four triple atoms, a quaternary atom and so on to a grossest mass of earth. The qualities that belong to the effect are inherent in the integral part of primary particle.[9]

The dissolution of substances occurs inversely. When some action is induced in a substance by pressure attended with velocity or by simple pressure, disjunction ensues. And then the integral substance consisting of those members is resolved into its parts and is destroyed, for it ceases to exist as a whole.[10]

Kaṇāda has elaborated the qualities of substances also. P.C. Ray points out that the definition of light as a substance hot to feel *(Tarkasaṅgraha)* is something remarkable, which has the implication that heat and light are identified as one substance.[11]

According to Vātsyāyana (4th century AD), chemical change may occur either by the application of external heat or internal heat.[12] In *Kiraṇāvali,* Udayana (11th cent AD) considered solar heat to be the ultimate source of all heat required for chemical changes of earth. He thought that solar heat was the cause of change of colour of grass[13], ripening of mangoes, changes in smell, taste and colour. Rusting of metals (sūrya pāka) and conversion of food into blood were also caused by it. [14] All these are instances of chemical transformation by heat.

The Jaina philospher Umāsvāti in his, *Tattvārthādhigamasūtra*, analyses the basic structure of substances.

Jaina philosophers acknowledge nine substances. One of these is ajīva. Ajīva is divided into five. The first four are amūrta. The mūrta padārtha is called pudgala. Pudgala has two states, aṇu and skandha. Aṇu is eternal and ultimate. Skandha may vary from dvyaṇuka to anantāṇuka.

The analysis of how various aṇus mix together to form substances is an original part of the atomic theory of Jaina philosophy. Only if two atoms are of viṣamaguṇa can they mix together. If these guṇas are weak, no mixing together takes place. The samyoga

also differs in accordance with the characteristics of each aṇu.

The nature of substance produced from the samyoga differs in accordance with the difference in samyoga. Prof. B N Seal opines that this may be an earlier form of the ionic theory of modern chemistry.[14]

Arthaśāstra (3rd century BC)

Arthaśāstra of Kauṭilya is considered to be a mine of knowledge, which is true in the case of Indian chemistry also. There are a number of references in it about mines and factories, the characteristics and origin of the ores of gold, copper, silver, lead and iron. The Superintendent of Mines was called akaārādhyakṣa. He is supposed to have knowledge of the methods of finding the source of ores, the veins of metals and their quality.[15] The kinds of metals obtained from the mines are also mentioned. During Kauṭilya's time treasury had its own mines.

The melting of metals was called *dravaṇa* or vilāpana. Solidification of metals is termed mṛti.[16] Heating was the most important process in the alloying metals. Descriptions of the characteristics of the ores of silver, copper, tin and iron are given in the *Arthaśāstra*.[17] Coins were made using different metallic alloys. The various impurities found in ores are also referred to.

One can also find the description of fermenting alcoholic liquids in *Arthaśāstra*.

Āyurvedic texts

Important Āyurvedic texts like *Carakasamhitā* and *Suśrutasamhitā* (1st century BC) speak of chemical aspects of the functioning of human body, digestion, and that of medicines.

Carakasamhitā

Caraka classifies objects into three, viz., animal products, vegetable products and products pertaining to earth.

He describes the nature and preparation of alkali (kṣāra) and gives

a few instances of minerals and metallic preparations. Certain minerals like sulphate of copper, sulphate of iron, realgar, orpiment and sulphur in combination with vegetable drugs are prescribed by him for external application for cases of ring worm, eczchema, leprosy etc.[18] He speaks of pill iron compound[19], powder of pearl compound[20] and iron, gold and silver tonics.[21] Rasāyanacikitsā prescribed for longevity etc includes many of these metallic preparations.

Suśrutasamhitā

The portion in *Suśrutasamhitā*, which explains the preparation and use of alkalies, occupies a prominent place in Indian medical chemistry. It is said that alkalies were used to clean surgical instruments, which were used to cut the diseased parts of human body. (The term kṣāra itself means that which removes away the affected parts of the body). Plates of iron, silver and gold were dipped in alkaline liquids before mixing with medicines. Suśruta classifies alkalies into mṛdu, tīkṣṇa and madhyama. He gives the preparation of each category. Some of them are used for external application and some for internal administration. They are used externally for skin diseases like kuṣṭha, tumors, piles etc. and internally for abdominal tumors, indigestion, urinary deposits, intestinal worms etc. Devices to store them are also advised. According to him, the sharp, saline taste of alkali when mixed with acid becomes very mild and give up its sharpness. That is why acid neutralises alkali.

Different metals like bronze, iron, gold, silver, lead, copper, tin and different salts like rock salt and sea salt are enumerated in the *Samhitā*. Roasting of iron and other metals so as to render them fit for internal administration has been described. The thin leaves of metals were plastered with a paste of the salts and afterwards subjected to roasting and were converted into their respective oxides, chlorides or oxichlorides. This can be considered a crude process for the preparation of the metallic salts.[22]

Bṛhatsamhitā (6th century AD)

Varāhamihira, in his *Bṛhatsamhitā,* refers to mordants like alum and sulphate or iron for the fixing of dyes on textile fabrics. It also alludes to cosmetics, scented hair dyes, perfumes etc. It also contains information on various cement preparations, which may be classified under two heads: rock cement (vajralepa) and metal cement (vajra samghāta). These varieties of cement were applied to the walls and roofs of temples and other buildings.[23]

Alchemy in Tantric Period (800 - 1600 AD)

The flourishing of Chemistry in India, especially alchemy, has an interesting phase during the period of tantra. The tantric cult in India was an admixture of alchemical processes on the one hand and grotesque rites on the other, centered on the worship of Śiva and Pārvatī. We also have a class of tantras, which is an admixture of Buddhist and Śaiva cults. *Rasaratnākara* ascribed to Nāgārjuna belongs to this category. According to tantric cult, a man should preserve his body by means of mercury and medicaments. According to tantrics, mercury was produced by the creative conjunction of Śiva and Pārvatī and mica was produced from Pārvatī. The combination of mercury and mica was believed to be destructive of death and poverty.

Sarvadarśanasaṅgraha of Mādhava which elaborates the sixteen philosophical systems current in 14th century AD, includes raseśvaradarśana or mercurical system as one among them. According to this darśana, different preparations of mercury can enable a man to be free from old age and death, ie., to obtain *jīvan mukti*. Rasa is called *pārada* because, it enables one to overcome the wordly affairs.[24]

In relation with Āyurvedic and Tāntric knowledge, a special branch of science was developed, ie., rasacikitsā. The knowledge that mercury could make structural changes in substances was a turning point in the history of chemistry. Metals and medicines were turned to medicine using mercury. The very same knowledge is the basis of rasacikitsā. Earlier drugs of herbal origin were used as medicines because of their natural and easy availability. But gradually, metals, minerals and

chemical substances came to be used as medicines for various external and internal diseases.

Rasārṇava of unknown authorship, *Rasaratnākara* of Nāgārjuna and *Rasaratnasamuccaya* of Vāgbhaṭa are some of the important works of Indian alchemy written during the tantric peried. *Rasartnākara* and *Rasārṇava* are tantras pure in which alchemy is incidentally dealt with. *Rasaratnasamuccaya* is a systematic treatise on pharmacy and medicine. *Rasaratnākara* of Nāgārjuna contains descriptions of alchemical processes and preparations of mercurical compounds. Extraction of zinc, mercury and copper are described by him. He also elaborates on the preparations of crystalline red sulphide of mercury (svarṇasindūra or makaradhvaja) which is used as medicine for many ailments.

There are also works written in regional languages like Tamil, Telugu, Kannada, Malayalam, Bengali, Marathi, Oriya an Gujarati on alchemy. Here, Tamil works on siddhavaidya, about two hundred in number, deserve mention. Works of Agastya, Nandīśvara, Romarṣi and Kailāsamuni are important among them. A comparative study of the alchemical ideas of these Tamil and Sanskrit works has not yet been initiated.

According to tantric cult, siddhis are two types - dehasiddhi (development of the body) and lohasiddhi (development of metals). The first pertains to making mercury capable of changing the molecules of lower metals into molecules of higher metals. Mercury, which is capable of this, can certainly transform human molecules also. This is dehasiddhi. Lohasiddhi is called alchemy or dhātuvāda. Dehasiddhi is obtained through lohasiddhi. Gradually, devices to refine metals led to the making of their powders, which were used as medicines.

As part of these alchemical processes, there are certain methods to purify mercury. Indian alchemists had adopted 18 methods for this purpose.[25] They also make classification of chemical substances into mahārasa, uparasa, dhātu, ratna and viṣa. Certain refining processes of metals and mine products, mixtures of

mercury also deserve special mention.

An important feature of Indian alchemy is the description of certain plants used in alchemical processes. About two hundred plants are referred to in this connection. We get an elaborate description of the labortaries and the instruments from these alchemical works.

Metal Works

The metal workers in India had made complicated idols from bronze and copper. The iron pillar in Qutab near Delhi, which weighs ten tones and in 1500 years old, certain iron beams in the temples of Puri and Konarak in Orissa and Rajasthan, prove the advancement of metallurgy in India.

It is to be pointed out that as part of a study of the different branches of different folk traditional knowledges of Kerala, much evidence has been found regarding centuries-old iron production in Malabar[26], especially in Malappuram and Palakkad districts. The place names related to iron production (Irimpuzhi, Ūtalakunnu, Ālapparambu etc), the ore deposits (ayiru maṭa) hidden in bushes, 'Kīṭa kallukal' which are the sediments of iron production, and the remains of melting points of iron production are the existing evidences of once alive iron production practices in Malabar.

Fifteenth and sixteenth centuries were famous for the manufacture of guns also.

Manufacture of Paper

The technique of paper making probably came to India from China through the Arabs by about 11[th] century AD. Before the emergence of paper Indians preserved their knowledge in tālapatras or bhūrjapatras. But in about 15[th] century AD paper was made by mixing lime and soda with pieces of rags. There were paper making factories in Punjab, Bihar, Bengal, Gujarat, Mysore etc.

The Chemistry of Fireworks

Books on fireworks are available in various languages like Sanskrit, Tamil, Marathi and Malayalam. The various ingredients that

go into the preparation of explosives were the following: saltpeter, sulphur, charcoal, iron powder, mercury, copper etc.

Conclusion

The theories and practices relating to chemistry held a prominent place in different areas of learning in India. As pointed out by P.C. Ray, the general notions about the factors that obstructed the gradual development of Indian science include the following factors.[27]

1. Education in India not being secular and universal, and professions being hereditary and caste-specific, the technical skills and knowledge became confined to certain sections of society. The intellectual community in society did not have active interaction with the practitioners of various sciences like the artisans etc.

2. The other-worldly attitude propagated by certain philosophical Schools like Advaita resulted in the discarding the empirical world itself and as a corollary, empirical sciences.

3. Colonial intervention which destroyed indigenous sciences and knowledge systems.

But it is felt that the science of rasacikitsā does not fully conform to these observations. Rasacikitsā which is widely practised in north India is indicative of the living aspect of the ancient Indian scientific heritage. It originated and flourished in the post-Śaṅkara period (800 - 1600 AD) with tantric spirituality based on Śaiva and Bauddha āgamas. The popular notion that spirituality is essentially antithetical to scientific spirit is to be rethought in this context.

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Structure and Evolution of Matter: Sāṅkhya-Vaiśeṣika Dichotomy

K. N. Neelakantan Elayath

The contribution of both idealistic and realist philosophers of India to the general fund of science and scientific methodology cannot be underrated. Many basic scientific concepts and methods in the investigation of physical phenomena are dominant in their thought. In their investigation they discussed many issues like the criterion of truth, observation and fallacies of observation, theory of inference and ascertainment of causal relation. Among these the cause-effect relation is one of the major tools of scientific investigation employed by Indian philosophers. The examination of causal relation resulted in two apparently contradictory theories called the theory of change (pariṇāmavāda) and the theory of new creation (ārambhavāda) formulated by Sāṅkhya and Vaiśeṣika philosphers respectively. Both concepts are not hypothetical but outcome of the observation of natural phenomena.

Application of Causal Theory

The application of these two theories of causation is in explaining the origin and evolution of physical matter. Different theories on the origin of the material universe frequently figure in Indian religions especially in the context of cosmological speculations. These speculations later appear as distinctive scientific theories in Sāṅkhya and Vaiśeṣika systems.

Pariṇāmavāda

According to theory of change formulated by Sāṅkhya there is no production of a thing previously non-existent. Technically known as pariṇāmavāda / satkāryavāda the theory establishes that the creation is nothing but the manifestation of a quality already existing in the cause in a potential form. The effect already exists in the cause in unmanifest form. Thus the oil exists in sesamum seeds, statue in the stone and curd in the milk. The causal operation renders that manifest which was formerly in an unmanifest form. This seems to be based on the principle of conservation of energy, which says that the total energy remains the same while the world is constantly evolving.

Pariṇāmavāda Applied

The Sāṅkhyas apply this theory of causation to explain the formation of the material universe. Accordingly all the material objects are evolved out of the primeval matter called prakṛti whose constituents are the three guṇas : sattva, rajas and tamas. They are held in equilibrium. The process of prakṛti, once its equilibrium is upset, is called evolution. Guṇas are not qualities or properties but units of existence. These guṇa-substances are combined in different proportions and different substances with different properties evolve.

Process of Evolution

The first product to evolve from prakṛti is mahat, the basis of intelligence and from Mahat self-sense or ahamkāra is produced. From the tāmasic aspect of ahamkāra (called bhūtādi) with the help of energy or rajas is produced the five tanmātrās - the subtle elements or infra-atoms. The bhūtādi from which the tanmātrās are produced is absolutely homogeneous, inert and possesses no qualities except mass. It is sometimes compared to primieval atom of the Big Bang theory, which contained the entire mass of the universe. The name tanmātrā suggests that it is structureless. These are the fundamental particles of matter. The five tanmātrās are the śabda, sparśa, rūpa, rasa and gandha (the essence of sound, touch, light, taste and smell respectively). These infra-atoms are said to be non-specific (aviśeṣa) because the specific characteristics

of their inherent properties are not yet manifested in them. They are inert but possess quantum or mass. These tanmātrās combine to form larger units called atoms or paramāṇus, which can act as sense-stimuli. Photon, the elementary particle of light of modern physics, can be considered as corresponding to the light tanmātrā of the Sāṅkhyas.

It is said that tanmātrās combine to form large units called atoms. In the process of evolution, the ether-atom is produced from sound-tanmātrā, the sound-tanmātrā in conjunction with touch-tanmātrā produces air-atom and so on. Thus each succeeding gross element has more attributes than the preceding one because there is a large number of tanmātrās causing it. These atoms correspondingly have all the properties of the tanmātrā. The ether-atoms, thus possess penetrability, air-atom pressure, light-atom radiant heat and light, water-atom viscous attraction and earth-atom cohesive attraction. Various other properties of gross matter are also enumerated in later Sāṅkhya and Yoga works.

The theory of pariṇāmavāda cannot be understood except in terms of the principle of conservation of energy. The guṇas of prakṛti are infra-atomic quanta of real and are forces rather than substances. All the materials are produced by the permutation and combination of these guṇas. This is well explained in *Yogabhāṣya* when it describes the important features of these guṇas. In the new productions the aspects called dharmas constitute various modes of the guṇas. They never get increased or diminished. Change according to Sāṅkhya after all is only a formation of new collocation and not entirely new creation.

Ārambhavāda

Against this axiom of Sāṅkhya, Vaiśeṣikas propose asatkāryavāda, also called ārambhavāda or paramāṇukāraṇavāda. Accordingly anything that is produced is a new creation. Though it presupposes a cause, the effect is not contained implicitly in the cause. Atoms of the four elements earth, water, fire and air are the ultimate unit of matter and all physical objects are combinations of atoms. Hence creation means combination of atoms in different forms. Only combination of atoms one produced or destroyed. The material and instrumental causes

possess some power within it and their collocation destroys the cause and creates the effect, which did not pre-exist in the cause. In other words, that which is produced was non-existent. In order to make something a cause it should be invariably and unconditionally antecedent (*niyatapūrvavṛtti)* to the effect. The operation of the cause is analyzable into molecular motion. It is sometimes interpreted as, 'the test of the expenditure of energy'. Effect is the sum of the operations of different causal conditions. The pot does not pre-exist in the clay, it is a new production, for a new purpose is served by the new creation. The material with which an object is made is called samavāyikāraṇa (and not *samyoga)* to show its intimate connection with the effect. However, Vaiśeṣikas hold that the qualities of the cause are the causes of the qualities of the effect except in certain causes like the operation of heat in production.This, in short, is the theory of new creation.

Application of the Theory

On the basis of this axiom Vaiśeṣikas explain the process of matter-evolution in a different way. Accordingly the fundamental particles of matter are atom of earth, water, fire and air. They eternally exist, unchanged and have permanent qualities.Though eternal, they are non-eternal in their gross aspects. Their nature is spherical (parimaṇḍala) and is the ultimate unit of matter, which has no further structure. The atoms of the respective elements carry all the sense qualities like colour, taste, smell and touch. In addition to this number, heaviness, and liquidity are also qualities of atoms. Among the substances ākāsa or ether is inert and has no atomic structure.

Process of Formation

Each atom possesses an inherent vibration (parispanda) and by an original tendency unites with another atom to form a binary molecule (dvyaṇuka). When they unite in pairs they produce homogeneous qualities in a binary molecule. The only exception is when a chemical action takes place in earth-substance due to the action of heat.

Regarding the origin of larger matter like triads (tryaṇuka) different views persist. Some atoms unite in pairs and other in triads

and tetrads. It can unite in two ways either by uniting in groups of three, four, etc., or by successive addition of one atom to each preceding aggregate. In the second case the triad will be a combination of three atoms and not three binary molecules as represented by the orthodox Vaiśeṣika view.

According to Praśastapāda, however, three binary molecules are grouped by three, four etc., to form different isomeric modifications. Varieties of substance are due to the differences in the arrangement of the molecules (vyūha / avayavasanniveśa). These groupings account for specific characteristics manifested in these isomeric substances. But when heat is applied to earth-objects it decomposes their atoms and changes their qualities. This view is held by pīlupākavādins among Vaiśeṣikas. The later Vaiśeṣikas speak of a different combination in the formulation of chemical compounds, mono-bhautic compounds and hetero-bhautic compounds. This, in brief, is the process of formulation of matter in Vaiśeṣika system.

Both Sāṅkhya and Vaiśeṣika theorists hold that the objects of this universe are ultimately evolved out of matter. While the latter considers atoms of the four elements as the basic building blocks from which material world originated, the Sāṅkhya goes a step further and postulates a structure less infra-atoms tanmātrās as the ultimate source of matter. Here atoms are produced at a later stage of evolution. According to both, atoms have qualities. In Sāṅkhya they are inherited from tanmātrās. In Vaiśeṣika they are taken to be permanent qualities and appear in subsequent formations. So there is no real contradiction in the atomic theory of the constitution of matter with the Sāṅkhya theory of their constitution from the primordial matter.

The theory of Sāṅkhyas that the effect pre-exists in the cause in a potential form is based on the principle of conservation of energy. Vaiśeṣika's perception of causality takes into account the creative aspect of material objects. This is because the created object serves a new purpose, which cannot be done by the cause. And thus every effect beginning from dvyaṇuka is a new creation. Yet they admit that the qualities of atoms are carried into the new production. Both deal with the problem of change and stress the fact that change is not total as

Buddhists conceive.

Though there are elaborate discussions on the tenability of these views on production in Sāṅkhya and Vaiśeṣika works, the main issue seems to be philosophical and metaphysical rather than scientific. This is because both were philosophers and were essentially dealing with formal science. If we take it as a scientific methodology, both these schools were looking at the evolution of matter from different perspectives and were trying to settle the problem of change.

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Atomism in Indian Systems of Thought

P. M. A. Rahiman

India had witnessed the impact of the attacks of different cultures ranging from the Greek to the Mugal, by which she was influenced in varying ways. But one thing, amidst all this cultural give and take, should be remembered with due gratitude that these foreigners in general did not harm the spiritual integrity of Indian thought. Moreover many rulers encouraged and helped to heighten its perfection through debates and discussions of various Schools of Indian philosophy. The nucleus of the cultural history of India is its philosophical thoughts.The concept of the creation of the universe, developed by all schools of philosophy of India has the *Aṇusiddhānta* or atomic theory, as its axis.

From the very early stages of Indian thoughts, the idea of Aṇu or atom was prominent. Even in the Upaniṣadic period, we can see ample references to this word. (*anuḥ panthā vitataḥ purāṇo-- Br.Aran.Up.*1V.4.8 & *aṇoraṇīyān mahato mahīyān Kaṭh.Up.*11.13). It is found to be used to denote the measurment of a matter.Yāska, the author of *Nirukta*, who lived centuries before Pāṇini, used the word *aṇu* to refer to the minutest measurement, which was considered to be the smallest basic unit of any matter. Thus it is evident that all the teachers of that period had known about atomic existence of the matter (bhūtas).

Moreover the Naiyāyikas and Vaiśeṣikas, who took the atomic

theory as an important principle and discussed its possibilities in the creation of the universe, use this word to refer to a measurement as well as to atom. (*aṇuparimāṇa- aṇu mahad iti tasmin viśeṣabhāvāt viśeṣābhāvācca. Vai. Sū. V11.1.11.na pralayo'ṇusadbhāvād. Nyā.Sū.1V.2.6. aṇusamyogastu apratiṣiddhaḥ. Vai.Sū.1V.2.4).*This aṇu is also indicated by the word paramāṇu since it shows the end of the concept of the minutest measurement.

We can see that there are two sects of thought based on the aṇusiddhānt*a* or atomic theory - those who accepted the existence of aṇu as the basic unit of matter (bhūtavastu) and those who did not accept this.

With regard to the attitude of cārvākas, the atheists, we do not have sufficient documents to prove whether they accepted the theory of atomism or they refuted it.The main reason for this is that there is no authentic work available to substantiate this, except for some quotations of the rival schools which were cited with a view to refute their views.

Jainism and Buddhism could be considered as the atheistic philosophies after this and we may examine how they dealt with this theory.

Jainism and the Atomic Theory

The important view of Jainism on the universal existence is that it is constituted of atoms. Matter is called pudgala which means that which is liable to integration and disintegration (*pūrayanti galanti ca*). The atom is accepted as the smallest unit of matter and hence cannot be divided. Compound objects (samghāta or skandha) of the material world including senses, mind, and breath, are the combination of atoms. Matter has four qualities of colour, taste, smell and touch, but not sound as sound is considered as a modifiction of matter. These atoms are considered to be the abode of souls. As the ancient Greek atomists Democritus and Leucippus, the Jains do not maintain any qualitative differences in the atoms. Since there is no difference of atoms in quality, it is indistinguishable. They are differenciated by developing the qualities of colour, taste, smell and touch. The distinction of elements

as earth, water, fire and air is secondary, and transmutation of elements is quite possible. Matter in its subtle form constitutes karma which infiltrates into the souls and blinds them to samsāra. But according to Jainism even the atoms would have effects because they also undergo transformation of colour by heat. This is because these qualities are attributed to it (ie.atom) in the secondary stage, as noted earlier.

The effects in the world are produced by the combination of atoms which are subject to mutual attraction.Two atoms form a compound,when one is viscous and the other dry, or when both are of different degrees of viscousness and dryness. Only the dissimilar atoms are combined together. The Jains too admit the attraction and repulsion of atoms.The movement of atoms is brought about by means of space, dharma, and adharma. The skandhas (compounds) combine with other skandhas. Thus pudgala exists in two forms - *aṇu* and skandha. The changes of the physical universe are traced to atomic disintegration or aggregation. The Jains do not accept the qualitative differences of primary atoms. In this matter Jains agree with Leucippus and Democritus. Moreover, the atom may develop a motion of its own so swift that it transverses in one moment the whole universe from one end to another. Thus the Jains accept the attraction, motion, and combining capacity of the atoms.

Buddhism and Atomic Theory

Among the Buddhists the Vaibhāṣikas and the Sautrāntikas accept the atomic theory.The effective objects (kāryajātadravya) are the results of the gathering together of the ultimate atoms according to their capacity. All objects are ultimately reducible to atoms. The Vaibhāṣikas maintain that the atom has six sides, and yet is one, for the space within the atom cannot be divided. They also hold that the atoms can be seen in a mass, though we cannot view individually just as we see a mass of hair, but not a single hair. According to Vasubandhu, an atom is the smallest particle of rūpa. It cannot be placed anywhere or tampled on or seized or attracted. It is neither long nor short or having no shape at all. It is indivisible, unanalysable,

invisible, inaudible, untastable and intangible (*Abhidharmamahā-vibhāṣā*). The atoms cannot penetrate one another. The Vaibhāṣikas and the Sautrāntikas do not admit dyads (dvyaṇuka) or triads (tryaṇuka) though they allow indefinite atomic aggregations. Bodies which are the objects of senses are aggregates of atoms. The unit possessing the qualities rūpa, gandha, rasa, and sparśa is paramāṇu or the ultimate atom which defies analysis. The paramāṇus become perceptible when they combine. The perceptible atomic unit is the aṇu which is a combination of paramaṇus. The atoms are the same in all the elements possessing the qualities of earth, air, fire and water. An object in the world will show the qualities of four elements but in some cases some elements display their active energy.

Thus they (the Vaibhāṣikas and the Sautrāntikas) hold that the smallest unit of matter is paramāṇu and it becomes perceptible by combination and the smallest particle of perceptible matter is aṇu. This aṇu has no differentiation of earth or water but by possessing qualities they become the material things of earth, water, fire or air. (Here Śaṅkara refutes this atomic principle of these two groups calling them sarvāstitvādin. *Brah.Sū.Bhāṣ.* 2.2.18).

When discussing on the rūpaskandha,Vasubandhu refers to an important theory of Buddhists, ie, the paramāṇus exist as a collection (sanghāta), not single. The Sautrāntikas also held that ākāśa is the same as the ultimate atom, since both are notions and nothing more.

Mīmāmsā and Atomism

Mīmāmsakas do not deny the existence of atoms. According to Prabhākara there are three eternal substances: time, space and atoms. But it is doubted that the word aṇu is used to denote the manas (mind) which is atomic in structure. But the *Prakaraṇapañcikā* of Śālikanātha (9 th century.A.D.) puts forward the view that adravyadravya - the uncompounded matter - is of two types-paramamahat and paramāṇu. Kumārilabhaṭṭa summarises the atomic theory, wherein, he explains this with suitable clarifications. The quality of colour

compared to blue etc becomes sāmānya. Again that blue compared to its special attributes becomes generalized. While coming to the stage of paramāṇus even dyads become a general phenomenon because it rests upon two paramāṇus. (*....nīlādīnām samānatā / te cāpi tāvat sāmānyam yāvat syuḥ paramāṇavaḥ/dyaṇukasyāpi yadrūpam taddhi sādhāraṇam dvayoḥ//*) By that last particle (*antyena viśeṣeṇa - paramāṇunā*) we can have no transaction. We cannot see it alone or with any other group. When a group is formed the atomic character of a matter does not vanish. Pārthasārathimiśra (10 th century.A.D.), the commentator of Kumārilabhaṭṭa, in his *Sāstradīpikā* undoubtedly establishes that paramāṇu is the minutest unit of matter. But in *Manameyodaya* (17th century A.D.) the atomic theory of Nyāya-Vaiśeṣikas was refuted and it is claimed that the smallest unit is triad (tryaṇuka) as there is no evidence to accept an invisible (*jālarandhravitejojāla-bhāsurapadārtha viśeṣān alpakāniha punaḥ paramāṇūn kalpayanti kumārilaśiṣyāḥ tadatirikta pramāṇābhāvād anupayogācca tadatiriktakalpanasya....*)

According to Prabhākara the material things exist in their general form as they are conceived in that form.The constituant cause of them is paramāṇus and auxiliary cause (asamavāyikāraṇa) is the combination of paramāṇus. If the soul is omnipresent what may be the driving factor of that movement is to be explained.

Mīmāmsakas do not admit that movement (atomic motion) for the principle of movement is the energy which moves the atoms and this is possessed by the omnipresent soul. It is by the energy imparted by it (soul) to the body that the latter (paramāṇu) moves.

In short, even the atomic theory was familiar to the Mīmāmsakas, they were not bothered about the logical or scientific perfection of it.

Sāṅkhya and Atomic Theory

The Sāṅkhya system accepts the material world consisted of earth, water, fire, air and space. But they hold them (earth etc.) on their material aspects; not how the senses accept their cognition. According to them five classes of atoms are generated.The sound potential, generates the

ākāśa atom. The touch potentials combine with the vibratory particles (sound potential) to generate the Vāyu atom. The light and heat potentials combine with touch potentials to produce the tejas atoms. The smell potentials combine with the preceding potentials to generate the pṛthvī atom. Touch potentials and sound potentials generate ap atoms. The ākāśa atom possesses penetrability and so on. Thus we can see that any collocation of atoms forming a thing could not change its form, unless the barrier inherent or caused by the formation of the present collocation could be removed by some other extraneous instrumental cause.

Here it is noticed that the eternal existant matter is Prakṛti (mūlaprakṛti) and all material things are its constitutional arrangements (sanniveśaviśeṣa.). The tanmātras as well as the atoms are the formative variation of this prakṛti and thus the minutest unchangeable unit of matter is not the atom for Sāṅkhyas.

The Advaita Vedānta School of thought does not accept the material world in its structural form and hence it is not necessary to estimate their stand on the atomic theory.

Now we may discuss two schools that analytically discussed the atomic theory with its scientific possibilities in detail.

The atomic theory of Nyāya-vaiśeṣika school is so natural to the human mind that early attempts at the explanation of the physical world assume this form.

Nyāya Philosophy and Atomic Theory

In the beginning stage Naiyāyikas and Vaiśeṣikas have their own views in connection with the atomic principle. Gautama, the propounder of Nyāya system refutes the delusion theory of Sāṅkhyas telling that it is impossible because of the existance of atoms (*na pralayo' ṇusadbhāvād, Nya. Sū.*1V.2.16). Even in the delusion all material things exist in the form of their atoms and hence in this universe there is no possibility of utter non-existence.

A detailed analysis of the theory puts forth the problem

concerning the all pervading and eternal nature of ākāśa. If it is accepted, then the eternity of atoms cannot be accepted. A matter which is mixed or combined with another matter cannot be eternal. Gautama explains that the contact of ākāśa, kāla, and dik should not be treated like other matters. These matters are over and above such considerations as these matters are entirely different from other matters like earth etc. (*ākāśavyatibhedāt tadanupapattiḥ / ākāśasarvamgatatvam vā / antarbahiśca kāryadravysya kāraṇāntaravacanādakārye tadabhāvaḥ / Nya.Su.1V.2.18-20).*

There is an argument that the atoms are not eternal since they are constituted of parts. In that case, a matter when combines with another it might have sides and if there are sides for a matter it can be split into parts. Here an atom has combination with other matter ie. ākāśa. Gautama refutes this argument saying that if we accept a view that the atoms have parts, then we could have multifarious splitting of atoms in particles and so on. Thus there will be no end to that process and there will be the defect of anavasthā. Moreover there can be no objection to the contact of an eternal one with another eternal one (*anavasthākārit vādanavasthānupapatteścapratiṣedhaḥ/Nya.Sū. 1V.2.25*)

The eternal atoms are incapable of division into parts. The atom marks the limit of division. If matter were infinitely divisible then we should have to reduce it to nothing and admit the paradoxical position that magnitudes are built up of what has no magnitude, bodies out of the bodyless.

Vaiśeṣikas and the Atomic Theory

The atomic theory was discussed in a clear and definite form in the *Vaiśeṣikasūtras*. These *sūtras* are written before *Nyāyasūtras* (vide S.N.Dasgupta: *Introduction to Indian Philosophy,*Vol.1 pp.276-83). The word aṇu is meant as paramāṇu and as the smallest unit.

The atoms are the material causes of effects. Though they are supersensible, they can be classified, though not from the stand point of size, shape, weight and density, but by a special differentiation or distinct individuality (viśeṣa*)*. The qualities which they produce in the

different forms of sensible things help us in the classification of atoms. The special qualities of sensible things are odour, flavour, luminosity, and temperature. There are four classes of paramāṇus giving origin to the four great classes of material objects - earth, water, light and air. These four classes of paramāṇus are said to produce the four senses of sight, taste, smell and touch. Fabric after fabric in the visible world up to the terrestrial mass itself may be dissolved, but the atoms will abide ever new and fresh, ready to form structures in the ages yet to come. (Dr.S.Radhakrishnan: *Indian Philosophy*,Vol.11, p.197). The Vaiśeṣikas hold that atoms do not exist in an uncombined state in creation. Atmospheric air is, however, an exception to this rule, since it is said to consist of masses of atoms in loose, uncombined state.The Naiyāyikas are not satisfied with this account. During creation they are said to possess a vibratory motion (parispanda). According to them, only dyads produce things. The three dyads produce the triad, which has a dimension which is apprehended (anubhavavedya) as having the size of a mote in the sunbeam (*jālasūryamarīcistha*). Here it is important to note that the general rule, which tells the qualities of the causes produce corresponding qualities in the effect, is to be exempted. But this quality of effect is derived from the distinct individuality of the cause, atom. Moreover it is significant that the atom which are material causes of the dyads are eternal and cannot be destroyed. The dyads are destroyed, not by the destruction of the primary atoms, but by the destruction of the conjugation of the primary atoms.

Ancient Naiyāyikas hold that by the destruction of the effect, the causes are also destroyed. But this is not in the case of dyads where the conjugation alone is destroyed. But later Naiyāyikas hold that, here, the act of destruction refers to the destruction of the conjugation only. However, the pīlupāka and piṭharapāka too are to be taken into consideration. The Vaiśeṣikas take that the change in temperature (*vijātīyatejassamyoga*) produced the change of colour, taste, smell and touch only in the case of atoms not in the material thing as a whole. But the Naiyāyikas argue that the change is brought into the material as a whole, and not to its components (atoms). This

change occurs by the influence of heat that enters into its inner parts through the small holes of the material effect.This is called piṭharapāka. Anyhow both schools accept heat as the main agent of the transformation of taste, colour etc. of material effects.

According to Udyotakara (111.1.4) there is no difference between an atom of a barley seed and a paddy seed, as these are all but atoms of earth.Under the continued impact of heat particles the atoms take new characters. It is heat and heat alone that causes the transformations of colours etc. in the original bhūta substances. Praśastapāda holds that in the higher compounds of the same bhūta the transformation takes place (under internal heat) in the constituent atoms of the compound molecules, atoms specially determined as the compound and not in the original atoms of the bhūta entering into the composition of the compound. Thus in the fertilized ovum, the germ and the ovum substances, according to the Vaiśeṣika view, are both isomeric modes of earth (combined with other bhūtas) are broken up into homogeneous earth atoms, and it is these that chemically combine under the animal heat and the force vāyu to form the germ (kalāla). Then the germ plasm develops, deriving its nutrition from the blood of the mother, the animal heat (jaṭharāgni) breaks up the molecules of the germ plasm into its constituent atoms. These germ plasm atoms chemically combine with the atoms of the food constituents and thus produce cells and tissues (*Nyāyakandali*, pp 33-34).

Here we have the changes and formations of the bhūtas of two or more. This is another type as in the case of oil, fat etc. This is called upaṣṭambha. Another significant milestone in the study is Udayana's view that the solar heat is the source of all the stores of heat required for chemical change. Thus heat may strike the atoms in a peculiar way, so as to break up their grouping, transform the physico-chemical characters of the atoms, and again re-combine them, all by means of continual impact within conceivable velocity, an operation which explains all cases of chemical combination.

The atomic theory of Nyāya-Vaiśeṣika school is not based on Vedic

testimonials. But the theoreticians of those Schools are found to be indifferent to this. (Udayana, very much tiresomely tries to establish the aṇusiddhānta derived from the Upaniṣadic Schools). Moreover the atomic existence is confirmed through inference as these atoms are not subjected to perception (Śrīdhara: *Nyāyakandali-aṇuparimāṇatāratamyam kvacid / viśrāntam parimāṇatāratamyād / yatredam viśrāntam yataḥ paramāṇu nāsti sa paramānuḥ //).*

Then the combination of two atoms to become a dyad is doubtful. The combination occurs between two objects having sides of external surface. Conditionally these atoms are in the space and there itself the combination occurs. There is no prohibition for this combination and thus the dyad is generated and then by three dyads the triad is originated and then only the component-compound relation is accepted.

The basic cause for the combination of the atoms is well discussed. Vaiśeṣikas do not accept the theories of Jains that some atoms are viscous and others are dry and thus they combined together. They hold that all atoms have their own individual speciality (viśeṣa). There is no difference from one atom of a matter (bhūta) with another atom of the same matter. They accept the dharma and adharma as the reason for the provocative cause of combination of atoms. Later they accept an unseen power (adṛṣṭaśakti) which became the cause of combination. (Udayana took this force as of Īśvara and after him Īśvara was accepted as instrumental cause). Some take that this power is put into the atoms themselves. This power when worked with each other the production process of material things is carried out. When this power is released it is very much useful and current in this day to day life, according to the Yoga philosophy.

There is an opinion that these atomic theories were inspired by Greek thought and arose possibly at a period when India was in contact with the western world, where the doctrine was widerspread (Keith: *Indian Logic and Atomism*, pp.17-18). But it is not a factual statement. Apart from the general conception of the atom as

the inseparable unit, there is nothing common between the Greek and Indian versions of atomic theory. According to Democritus, atoms have only quantitative differences and not qualitative. He thought the atoms are differed in figure, size, weight, position and arrangement but no difference in quality and divisibility. But Kaṇāda confirmed that each atom possesses its own distinct individuality (viśeṣa). The Indian schools do not accept the Greek view that secondary qualities are not inherent in the atoms. For Democritus and Epicureus, the atoms are in motion by nature, while for Kaṇāda they are primarily at rest. Democritus held that it is possible for atoms to create souls, while Vaiśeṣikas take soul and atoms as co-existent. The Greek atomists are of the opinion that the atoms, infinite in number and diversified in form, fall through boundless space and dash against each other, since the larger ones are moved more rapidly than the smaller. Thus falling into vertices they form aggregates and worlds. The changes in the motions of the atoms are said to occur in an incalculable way (Wallace: *Epicureanism,* p.100). But the Vaiśeṣika view is coloured in a spiritual manner by accepting God as the cause of movements in atoms in the later period.

Nowadays these concepts differ much. Now mass is not an unalterable existent, but is said to vary with velocity. It is resolved into infinitesimal centers of electric energy, with no bodily support, scattered at relatively wide intervals and flying to and fro at incredible velocities. Heat, light and motion are found to have weight quite apart from the matter. The atom has now become a system of electrons which are units deriving their character from ether (space). The premier atomic theories are unable to explain such facts. In India, as well as in Greece, this hypothesis was put forward as a physical one to a large extent and not a scientifically proved principle. It is a conceptual scheme adopted to explain the facts of nature.

As mentioned earlier, the Greek atomism was propounded by Leucippus in fifth century B.C. and his disciple Democritus. The Atoma named by Democritus for atom refers to a substance which is not divisible. Empedoclus (5th century.B.C.) claimed that matter can be divided into four elements as fire, earth, air and water (Vide Samuel

Glasstone: *Source Book on Atomic Energy,* London, p.3).Scholars like Aristotle accepted the existence of atoms. John Dalton is accepted as spokesman of modern atomic principles. In *New Systems of Chemical Philosophy,* published in 1808, he suggests atom as the unit of chemical structure. But he uses the word atom and molecule synonymously.

It is interesting to analyse the decline of Indian theories of atomism and the development of Western studies. Our systems of philosophy became metaphysical and all systems in later period accepted the existence of God and nobody could think of anything over and above the God. But Āyurveda and Mathematics found their way to growth. It is possible that there was no other go but accepting the Indian systems of medicine which in its turn, necessitated the acceptance of the belief in God and so on. Moreover, Mathematics also was accepted as a branch of science, not against the theistic views, but as it helped the development of astrology which was blindly welcomed by the rulers and society of India. But other branches of science were neglected, not even neglected, but were suppressed since they made it a point to reflect the reality of things as they are, which at times went to the extent of questioning the very essence of the concept of Īśvara. This was unfortunately resulted in our ultimate loss - the loss of the role as the pioneers of scientific thought.



Sources of Energy - Some Vedic Concepts

P. C. Muraleemadhavan

'Energy' and 'matter' are two basic concepts of science. Modern scientific studies proved that energy is the root cause of 'matter'. This has a striking resemblance with the concepts of 'Brahman' and 'jagat' in Vedānta since the Brahman is the cause of 'jagat'. Recent studies in quantum Physics provide some vital inferences in the matter of the identity of both.

Vedic texts do possess much information on science. Semantically Vedic texts are multilayered. The scientific ideas are hidden in some of the layers and they could be extractecd only through some linguistic devices.

Logic is the pivot of all scientific advancements. Nyāya system enjoys the highest position in scientific thinking as the pramāṇaśāstra or the tarkavidyā , creditably for the reason that it has systematised epistemology and its approach very logical. Vaiśeṣika with its stress on ontology is clubbed with Nyāya to form the samāna system - twin system . Pramāṇa, regarded as a means leading to veridical knowledge, is in consonance with the present day scientific approach where proof is required and sought for, in order to arrive at any conclusion. The classification of entities into seven is conceptually logical and scientific. The methodology of approaching and analysing the subject in the characteristic of pūrvapakṣa and siddhāntapakṣa, the primaface view and the establishment of theory, even if appearing as hypothetical in

the beginning, is indeed scientific.

Though the widely discussed content of the Vedas is spiritul in nature, they contain plenty of information about the temporal world, within the broad description of yañja, mokṣa etc. Many basic concepts of modern mathemetics, physics, chemistry, life science, astronomy, aeronotics etc. in addition to āyurveda and sthāpatyaveda were discussed. A sincere effort has to be made to identify explicitly and implicitly, the scientific contents embedded in the Vedic texts.

Here I would like to point out some references mainly from *Ṛgveda (RV)*, revealing the insights of Vedic seers on sources of 'energy.'

RV deals in plenty, the subject matter 'energy'. It is said by Vedic seers that wise men kindled energy and force for the use of common man. According to Vedic Ṛṣis energy possesses different forms and names. At different places and various contexts, *RV* gives different names of energy like force, might, power and strength.

Seers in *RV* discuss the sources of energy in different maṇḍalas or books in different manner. In their opinion fire is the main source of energy, hence fire is addressed as ūrjāmpatī - the lord of Energy.

स त्वं ऊर्जां पते रयिं रास्व सुवीर्यम्
प्राव नस्तोके तनये (८.२३.२)

The relation between fire and energy is qualified as the relation between father and son. The very first hymn in *RV* starts with Agni (fire), the father of energy.

It is not simply because of the spiritual importance of Agni that it is extoled in high esteem as seen in Vedic rituals. Agni is the main source of 'energy' for wordly life. One seer says that Agni is powerful and pregnant with energy and it is covered on all sides by light and lusture. It shines brightly and cuts like axe. Several instances are quoted in *RV* to prove that fire energy was used by Vedic people for cutting, welding etc.

स हि पुरु चिदोजसा विरुक्मता।
दीद्यानो भवति द्रुहंतरः परशुर्नद्रुहंतरः (1.127.3)

In *RV* 20.15.9 starts with ऊ र्जो नपात् etc. the Ṛṣi states categorically that fire as the main source of energy provides security for long life. For achieving happiness, valour, amenities and long life, one has to depend upon Agni, the fountain head of energy. उर्जो नपात् सहसावन्निति त्वोपस्तुतस्य वन्दे वृषा वाक्। त्वां स्तोषाम त्वया सुवीरा द्राघीय आयुः प्रतरं दधानाः। (20.15.8)

Fire is highly potential, hence it is called jātavedas. Based on some semantic layers, it can be seen that mostly all the epithets of Agni in Vedic literature suggests its pregnancy of energy.

Because of the close connection of cause and effect, the words Agni and energy are used as synonyms by Vedic seeers.

The sources of energy are many. In *RV*, the hymn, 2.1.1,

त्वमग्ने! द्युभिस्त्वमाशुशुक्षणिस्त्वमद्भ्यः त्वमश्मनस्परि।
त्वं वनेभ्यः त्वमोषधीभ्यः त्वं नृणां पते जायसे शुचिः।।

speaks of different sources of energy visualised by Vedic seers. Water, stones, woods, herbs etc. are some of them. Under some scientific process the energy is said to be extracted from water.

In mantra 1.70.2 a statemenet is seen that both movables and immovables bear fire. Waters, forests, mountains are pregnant with this energy:

गर्भो अपां गर्भो वनानां गर्भश्च स्थातां गर्भश्चरथां अद्रौ
चिदस्मा अन्तर्दुरोणे विशां न विश्वा अमृतः स्वधीः।

Fire as energy and power was used for various purposes in a home. It is a power to be handled very intelligentlly, lest it might prove harmful.

Vedic Ṛṣis in general believed that fire from water is very much powerful. In one of the mantras it is depicted that the fire can be joined on the slopes of mountains and they are mighty impelling forces. This fire energy was used to make things move, to make them take a speed. It is stated that fire energy has stimulated the revolving abilities and propelled everything. Fire energy extracted from water was used in battlefields to destroy enemies. Fire energy is highly distructive hence we come across in Vedic mantras often the prayer- oh! fire! destroy our enemies in wars (*RV* 8.39.8) For the generation of the fire energy

from waters, some kind of wall or bridge constructions and formation of reservoirs are mentioned in *RV*:

त्वं नो अग्न आयुषु त्वं देवेषु पूर्व्य वस्त एक इरण्यसि।
त्वमापः परिश्रुतः परियन्ति स्वसेतवः नभन्तामन्यके समे।।

This gives some strong inference that waters from sea, rivers and reservoirs were brought into some comparatively limited pools for enkindling the fire energy (*RV* 1.23.23)

To extract the energy or power Vedic people used to churn waters with the help of deviated winds. Thus it is said:

ससृवांसमिवात्मनाऽग्निमित्था तिरोहितम्।
एनं नयन् मातरिश्वा परावतो देवेभ्यो मथिनं परि ।। (*RV*.3.9.5)

This method of extracting energy is being mentioned in several contexts in *RV*. *Atharvaveda* says:

हिरण्यवर्णाः शुचयः पावकाः यासु जातः सविता यास्वग्निः।
या अग्निं गर्भं दधिरे सुवर्णास्ता न आपः शं स्योना भवन्तु।।

(1.33.1)

Sun is also referred as a source of energy in *RV*. So they tried for the energy in the space. The seers have stated that the energy obtained from sun is not different from that which was obtained from plants, waters etc. Sun rays and heat collected from the wide space are instrumental in taking out the energy from waters.

Two different ways of extracting energy can be found in the matter of sun. The solar energy directly from rays and the energy from water with the help of solar rays and heat.

The extraction of energy from river waters is depicted in *RV* at several contexts like 2.35.3, 4, 9, 12 etc. Rivers mix in one another, and while mixing, the waters whirl with speed. Waters are flowing turbulantly. Energy is created in this process. The seers say that the fire is surrounded on all sides by the turbulant waters. The waves of waters brushing, hitting and clearing the fire. Ṛṣi says that the fire is shining without fuel and this fire is covered with vidyut (electricity):

अपां नपादा ह्यस्थादुपस्थं जिह्मानमूर्ध्वो विद्युतं वसानः।

Ṛṣi is keen in explaining the fire energy, that this energy can be touched or lifted by wooden handles (bad conductors): You cannot touch it by naked hands or any other conductors of heat and electricity. From all these illustrations, some strong inference may come in our mind that the energy mentioned in Vedic texts is something like electricity of modern times.

RV in one context states that the wind made his ten wives to give birth to fire energy. As in the case of sun, the wind also directly produces energy and also is instrumental for extraction of energy from waters. The process was of whirling the waters as is done in taking out butter.

The creepers, plants and herbs produce energy. One Ṛṣi says that fire and heat are one and the same, since the whole of the herb is full of fire:

त्वं गर्भो वीरुधां जज्ञिषे शुचिः (*RV* 2.1.14)
उत्तानायां जनयन्त सुषूतं भुवदग्निः पुरुपेशासु गर्भः।
त्वं ओषधीभ्यः जायसे शुचिः (*RV* 2.1.1)

It is said that the creepers are in sleeping position on earth when they deliver fire. Kālidāsa in *Kumārasambhava* depicts one nīpa tree releasing heat in the night by absorbing heat of sun at day time. Again in *Raghuvamśa* a plant named tṛṇajyoti shedding light in the night is described thus:

अथाग्र्यमहिषी राज्ञः प्रसूतिसमये सती।
पुत्रं तमोपहं लेभे नक्तं ज्योतिरिवौषधिः।।

Mallinātha in his commentary on this verse says that this herb burns at night: तृणज्योतिराख्या लता, सा हि रात्रौ ज्वलतीति प्रसिद्धिः

References can be seen in Kālidāsa again in *Raghuvamśa* (9.70) (ज्वलितमहौषधिदीपिकासनाथं) and in *Kumāraambhava* (महौषधिं नक्तमिवात्मभासः). In *Meghadūta* in more than one context the emitting of light by precious stones are depicted.

There are several references in *RV* of a peculiar energy extracted from wind, by making it pass through some hillocks. The wind blows with increasing velocity. Energy produced thus was used as power for generators or mills.

The sources of energy referred in Ṛgvedic hymns, as said earlier, are many. They deserve serious study in the light of modern science. It is clear beyond doubt that the Vedic society used such varieties of energy in their day-to-day life.

Among sources of energy fire, water, sun, wind, trees, herbs, plants and stones can be seen. Among them fire, water, sun and wind play an important role. They produce separately and jointly. Mostly all these sources are extracted by the modern science for production of energy. This is not merely something accidental. Some serious study in the field is required, especially in a context when India faces an acute paucity of energy.

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SECTION III

Architecture and Environmental Sciences

Indigenous Knowledge Base of Traditional Architecture of Kerala

A. Achyuthan and Balagopal T.S. Prabhu

The archeological monuments, the vernacular and Sanskrit texts and the hereditary skill of traditional craftsmen formed the three sub-systems of the indigenous knowledge of the traditional architecture (vāstuvidyā) of Kerala.Their synthesis resulted in making this knowledge base a living heritage. Out of these, the most vibrant element in Kerala was the tradition of craftsmen, of which the timber craft attained a dominant role in building construction. The technological base of vāstuvidyā is contributed by the flexibility, perfection and variety of techniques of construction in timber. Canons and practices, developed for planting trees in appropriate locations, their selection and extraction for construction, shaping, polishing and assembling the timber scantlings into load bearing and load transferring structures as well as decorative and protective elements reached a level of perfection. Strategies to incorporate this knowledge base in construction will enrich the technology, economy and overall quality of building industry in Kerala.

1. Introduction

Taccuśāstra, the building craft, originated with the attempt of man to settle down and build artifacts to make the settled life convenient and safe. Its origin can be traced to all ancient cultures. But it is only in India, that it evolved continuously and spread through hereditary

tradition over the length and breadth of this vast peninsula. The building craft was modified to suit the regional variation. Over a time, these regional styles got canonised and came to be preserved as textual material among the practitioners. In regions subjected to cultural changes brought through earlier invasions or destruction through natural disasters, the traditions tended to disappear into obscurity. However, in areas which were relatively not affected by such devastating havocs, the craft knowledge retained its indigenous character, evolved to greater perfection and even transcended to the levels of a design theory and philosophy. Kerala is one such region where the indigenous knowledge base blossomed to the higher level of building science designated as vāstuvidyā.The vitality of this knowledge base continues to be at the realm of the operational level of the building craftsmen.

2. The Pañcakammālar

The five basic schemes in the building crafts are those of (i) iron smithy, (ii) metal work, (iii) gold smithy, (iv) stone work and (v) timber work. The guilds of these five streams evolved as social groups of 'aiṅkuḍi kammālar' or 'pañca kammālar'. They were associated in varying degrees of participation in all aspects of development works related to community sustenance viz. agriculture, construction work and transportation. For example, the blacksmiths provided the implements and tools for all work operations. In the context of building artefacts, their contribution covered making of implements such as cutting axes, saws, chisels, drills, planers and fasteners. The perfection of their work could be seen in the large range of chisels and other tools used by timber workers. The indigenous knowledge of black smiths covered the metallurgical science of ferreous metals and the technology of annealing, tempering, case hardening etc.

The metal workers developed indigenous technology for using metals like copper and zinc and alloys like brass and bronze. Their work covered forming or casting of utensils, lamps and icons. In the building construction, the craft reached the level of perfection in forming and covering of coppersheet roof frames and casting of brass and bronze

fastenings. The casting of complex forms with or without wax, grinding and surface finishing including that of metallic mirror is a unique craft side of metal worker, the indigenous base of which needs study and preservation today. The important role of goldsmiths is in the development of techniques in using precious metals like copper, silver, gold and their alloys. The properties of ductility and malleability of metals were effectively used for creating not only ornaments, but also filigree works, inlaying works, thin sheets, metal plating etc., all of which were employed in construction and decorative works. The precision and perfection required for such fine works gave gold workers a higher status in the heirarchy of artisans.

The Laterite Stone Masonry

The load-bearing and supporting system of the buildings comprised mainly of stones and timber and hence the role of stone worker and timber worker became significant and critical in the evolution of building technology. The selection of stone-quarries, choosing the appropriate type of stones, the dressing and jointing the stones, finishing the surface of stone masonry by plastering etc, formed the basic crafts of the stone workers. There are three components of stone working. The first relates to the technological properties of natural stones and their apt use. The vast laterite formation of Kerala was effectively used to obtain building blocks having unique characteristics of easy quarrying and dressing on the one hand and hardening on exposure to atmospheric air on the other. The blocks could easily be quarried and dressed while they were fresh. The second related to their use in construction. They could be assembled in a simple trabeated system or could be effectively, incorporated in corbelled arch construction. The latter was perfected in 'kadalīkaraṇa' method of forming stable roof for the shrines. It could be incorporated in masonry work with laterite quarry dust or in lime mortar. This becomes the third component. Experiments lead to the development of surkhi mortars with sand, laterite dust and lime, in the first stage. Development of tempered mortars using admixture of herbal juices and tree secretions was a notable achievement in obtaining strong, smooth and crack-

resistant mortar. In a method of forming huge icons, specially prepared composite mortars (kaṭuśarkarayoga) were applied on a frame work of shrub wood. Further a mortar of 8 components was also developed to fix stone to stone as an adhesive (aṣṭabandha). The indigenous knowledge of stone masons is getting lost by in the modern construction and needs strategies for preservation.

Architecture in Timber

The perfection of the building craft reached its pinnacle in the timber work. The timber worker preserved the knowledge base of the properties of large species of trees and their appropriate use under tension, compression, flexure, shear and bearing. Techniques for felling, seasouring, shaping, joining and preservative treatment were developed using indigenous materials and techniques. The importance of these was emphasised through rituals at different stages of operations. Timber was used as the base of well steining, walling of sacred structures and cladding for buildings. Doors, windows and other openings were developed indigenously combining safety, function and aesthetics. The structural use of timber found expression in column, beam, ceiling, attic and roof framing. Essential traditional Kerala architecture is architecture in timber.

This aspect is best illustrated in the timber wall construction and roof framing. The space enclosure by timber walling called "*ara* and *nira*", is a traditional method resembling the modern stud wall construction with the difference that it has a structural frame along the edges and diaphragm wall of decorated timber planks. The lower frame could be fixed to the basement while the upper frame was integrated to the roof construction. This unique technique was used for the storage rooms, the core house or even for the whole construction. In rare cases, it was adopted even for temples.

The timber roof frame evolved in Kerala is space-frame with six basic elements - wall plate, ridge, rafter, collar, pin and eave reaper (ṣaḍdāruka). For large span structures additional purlins (ārūḍhottara) supported on inclined struts (viṣkambha) were adopted to retain the

strength and form of the roof. For theater, diagonal bracing similar to the modern "lamella" construction was incorporated with roof frame. The speciality of the timber frames was that it could be assembled on the wall plate. It could be dismantled and reassembled if needed at the same site or elsewhere in case of relocation. The system is well adapted to prefabrication.

Decorative treatment of timber was integral to the structural system. The points of load transfer, the joining of members etc. became natural locations for decorative treatments. The decorative treatment of columns included pedestals, shafts, capitals and brackets. The ceiling incorporated waffle treatments, sculptural oranments and painting. The gable ends were projecting over the hipped roof as well as on the side, providing a characteristic feature of the timber architecture of Kerala.

The refinement of roof construction indirectly decided the shape and size of the building. The wood workers thus had the two additional functions viz. (i) providing the basic measurements for the building and layout of areas and (ii) ensuring the compliance of this layout right from the foundation laying. The master craftsman (ācārya - āśāri) thus became the de facto planner and designer as well. His services were sought for site selection, site layout, the foundation stone laying and every such stage of decision making in a building operation. This necessitated the widening and deepening of his knowledge to the niceties of design theory. Owing to this all important role of the wood craftsman (takṣaka) the indigenous knowledge of building craft come to be designated as "takṣakaśāstra" or "Taccuśāstra" in this region.

Design Grammar for Plans and Designs

Design in its broadest sense involves obtaining the best solution by decision making under a variety of constraints. The tropical weather with its heavy rain fall, high humidity and intense solar insolation necessitated protection of buildings from the effects of the elements. Heavy rainfall warranted sloping roof and high basements. Humidity necessitated ample air flow and hence an open system of planning,

staggered layout and design with thorough ventilation. The protection from solar radiation warranted low walls and large projecting eaves.

The consideration that house is a basic necessity was accepted by the society. Hence the plan was to be made simple as a rectangle. Economic considerations fixed the shape efficiency of rectangular shapes when more rooms were added to the core. The dimensional system was thus made modular and standardised. The proportion of width to lenght of the rectangular houses was limited to 1 : 3 to get a space efficiency of 0.66 in the floor area covered by unit perimeter. The dimensional system was evolved from the anthropometric measure of span (vyāma) into a scale of 'hasta' and 'aṅgula'. The module for measurement was 1 pada, the octal division of vyāma. The standardisation of rooms was effected by determining acceptable widths and perimeters. The dimensions of building in different orientations were normalised by the concept of yoni. There are rules for fixing the position of houses in a plot and also for entry to the plot. In short, the process of site planning and building design followed an algorithm and logic flow.

Harmonising the Building with Environment

The house was always treated as part of the living environment and as such, every effort was made to harmonise the artefact with its surroundings. Right in the selection of site for building, the three determinants are favourable terrain (sthala), hydrological (jala) and biotic (vṛkṣa) qualities (guṇas). Rules for determining them were evolved.

In the house layout, these three elements were given due importance by earmarking specific locations for groves, water bodies and trees. Canons were laid for the location of specific variety of trees and their distance from the building. These prescriptions appear to have been based on the flow/obstruction to the wind, solar radiation, beneficial effects of fruit bearing, flowering and medicinal use, foliage, root-spread, strength etc. of each variety of tree. For example the tamarind tree having good strength, foliage and useful fruits is prescribed for the SE location because it gives shades in summer and allows sunlight

in autumn and winter by shedding leaves.

Strategies for Preserving the Knowledge Base

Ingenious knowledge in vāstuvidyā is linked to many areas such as geography, hydrology, biology, astronomy, material science, engineering, crafts and arts. This link tends to become obscure and needs to be enquired and disseminated. The strategy proposed for this is given below:

1. The need for research and study for vāstuvidyā is to be recognised and facilities shall be created for them at the University level.

2. There are several institutions engaged in research in vāstuvidyā. These should be recognised as approved research centres by the Universities for the purpose of registration for M.Phil and Ph.D degrees.

3. The role of craftsmen in preserving the indigenous knowledge in vāstuvidyā with its dynamism and purity is to be recognised and facilities to bring them into the mainstream of technological education shall be created. The knowledge base at this level is not well documented because it is transmitted orally from the master to the trainees. Since the oral tradition is vanishing, this knowledge base which is the vibrant and most significant part of Vāstuvidyā is becoming obscure. An elaborate project to study this base and document it should be set into motion urgently. Such projects should get sufficient funding from Government and other agencies.

4. Efforts shall be made to educate the public regarding the relevance of indigenous knowledge of house building through non-formal edcuation by Government and voluntary agencies. For this, awareness courses should be conducted.

5. Documentation on the crafts should be encouraged by giving financial help for publications.

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A Survey of Works Relating to Kerala Architecture

S. A. S. Sarma

General Introduction

It is a matter of common knowledge that Sanskrit in addition to its well known and vast literature on poetry, drama, religion and philosophy, has a vast store of writings on technical subjects like astronomy, medicine, architecture, music, dance, law, polity and even horticulture and cosmetics. But while a good amount of the first part of the literature had seen the light, a lot of information still remains in manuscripts on the technical literature, which needs attention.

The Sanskrit literature dealing with architecture and iconography is voluminous and in addition to that, it is matched by a vernacular literature only known in the regions where it is produced.

An idea of advances reached during the Vedic times itself, in different disciplines can be visualised if one is aware of the several technical and semi-technical professions practiced during those days as mentioned in different contexts in Vedic literature. Among these professions are those of the carpenter [*takṣan, Ṛgveda* (*ṚV*) 9.112.1] smith (*karmakāra*, (*ṚV*) 10.72.2), one who smelted metal in fire (*dhūmātṛ*, Atharvaveda 3.5.6), plough-man (*kṛṣṭi* (*ṚV*) 1.177.4; 4.17.5) etc.

Kerala has had, from early times, a continuous and comparatively rich tradition of scientific and technical advances, as evidenced by the volume of literature on these disciplines presently available to us, mostly

in the form of palm leaf manuscripts. Kerala, a land of temples, has produced a good amount of technical literature, especially on architecture and astronomy. There is no doubt that the architects of Kerala were well learned in the field of *vāstuśāstra* and gifted with this art, such as the famous Uḷiyannūr Peruntaccan.

Tradition in Kerala architecture

There are four sorts of builders mentioned in the texts on architecture: *Sthapati, Sūtragrāhin, Vardhaki and Takṣaka.* The *Sthapati* should be fit to direct or instruct the construction and should be well-versed in all the traditional lores and must have crossed the ocean of the science of architecture. *Sūtragrāhin* is the disciple or the son of the architect who follows the directions of the latter. He must be equipped with the knowledge to make the rod and the rope fly and also should know how to measure length, height and proportions like horizontal and vertical. The *Takṣaka* is so called because he cuts of portions of stone, wood, bricks. He should be an expert in working in clay - a molder. The *Vardhaki* assembles and correctly erects the pieces cut by the *Takṣaka*. He works under the *Sūtragrāhin.*[1]

Uḷiyannūr Peruntaccan, the schools of Rāmanallūr, Tāmaranellūr[2] are some of the known artisans of Kerala. The family of Kāṇippayūr should be mentioned here towards their contribution in the field. Their publications on the subject of Kerala architecture, with the translation in Malayalam should be noted in this regard. The *Tantrasamuccaya, Manuṣyālayacandrikā, Gṛhanirmāṇapaddhati, Keṭṭiṭaṅgal, Śilpabhāṣā* etc. are some of their well known titles. Recently this family had started a Research Institute in Kunnankulam to encourage the study on Kerala *Tantra* and *Vāstuvidyā.* The *Tantravidyāpīṭha* of Aluva is also to be pointed out here.

Sanskrit Texts on Kerala architecture

Ptayogamañjarī (PM) of Ravi[3]

PM written by a Nampūtiri brahmin Ravi could be one of the earlier text among the tāntric texts produced in Kerala. His date has

been assigned between 10th and 11th century A. D.[4] The work is also known as *Śaivāgamasidhāntasāra.* The author gives the intention of the work, in the following stanza.

durjñeyāni bahūni mandamatibhis tantrāṇi gaurīpater
udgīrṇāni mukhāmbujād avikalās tv ekatra teṣāṁ kriyāḥ /
noktās tena śivāgamāṁś ca sakalān udvīkṣya tās tāḥ kriyāḥ
saṁkṣipya pravadāmi yāśca vihitā liṅgapratiṣṭhāvidhau //

Many *Tantras* preached by the lotus face of Śiva are hardly understandable by the dull-witted. Also their practices are not said in a place in their entirety. Therefore having consulted all the Śivāgama texts, I shall teach in brief various rites as well as those found prescribed in the texts on the consecration of Liṅga.

The text is divided into 21 *paṭalas* on different topics, among which certain *paṭalas* are devoted to subjects relating to temple construction. The second *paṭala* begins with the following verse:

ācāryaḥ śivamandiraṁ sukuśalaiḥ saṁprārthitaṁ kārayet
kartā śilpibhirādareṇa vidhivacchāstroktamārgānvitam /
pūrvaṁ tatra parīkṣya bhūmimasakṛt kṛṣṭāṁ tu tāṁ rodhayet
saṁkṣepeṇa vadāmi lakṣaṇamahaṁ bhūmeśca śāstroditam //

The Ācārya, the performer (of the examination) will get constructed the required temple of *Śiva* by skilled artisans with devotion following the methods prescribed in the scriptures (of architecture). First of all, after examining the ploughed land many times, he will get it fenced. I will say briefly the qualities of the land prescribed in the scriptures (in detail).

It gives in detail the qualities of the land required for the construction and the purification for the same. In the third *paṭala* it deals with the vāstuyāga to be performed before the construction and gives the story of the Vāstupuru a. Then in the following *paṭalas* it deals with the *iṣṭakānyāsa, garbhādhāna, prāsādalakṣaṇa, śilālakṣaṇa, Liṅgalakṣaṇa, dīkṣa, aṅkurārpaṇa, jalādhivāsana, rakṣoghnahoma,*

Lingaśuddhi, pratiṣṭhā, parameśvarapujā, caturthadivasasnapana, utsava, tīrthasnānavidhi, snapana and jīrṇoddhāravidhi.

The *Pradyota*, a detailed commentary on *PM*, of Trivikrma (15th A. D.), son of Nārāyana is of great value in understanding the *PM* properly. The authoritativeness of the *PM* can be noticed from references to it in the later works like *ĪGP*. The *Pradyota* are still in manuscript form and an edition of the same is a desideratum.

Mayamata[5]

Along with the *Mānasāra* the *Mayamata* forms one of the earliest works exclusively devoted to Indian architecture.[6] It is assumed that the work could have been produced between the 11th and 12th century A. D. In 36 chapters, containing about 3000 verses, the work deals, in detail, with various aspects of architecture, including house-building, construction of villages, planning of palaces, towns and cities, laying of roads, construction of vehicles and furniture and the installation of images of deities in temples. As such, it forms a comprehensive treatise on the subject.

Dagens, who had brought out the critical edition of the text, observes that the *Mayamata* occupies a fairly well defined place. It is a general treatise, a *vastuśāstra,* written in Sanskrit but originating from Dravidian India, most probably from the Tamil area; it is part of the aivite agamic literature without the connection being underlined by any pronounced sectarianism and its drafting must have been done during the Cola period, at the time when the architecture it describes had reached the peak of its maturity. [7]

Regarding the place of the work there is little doubt that *Mayamata,* has been composed in Tamilnadu or Kerala as attested by several considerations, such as its popularity with the local indigenous architects (*Sthapati*-s), the availability of its manuscripts only in South India in South Indian scripts, the geographical latitude as worked out from the section on *Apacchāyā* (ch. 6) being 11 North, which falls in Tamilnadu and Kerala and, last but not least, the occurrence of Tamil and Malayalam words in the verses.[8] In any case the South Indian

origin of the text cannot be questioned.

The *Mayamata* has been used as an authority in many works, such as the *Īśānagurudevapaddhati*, which quotes it extensively when dealing with architecture, and in the *Śilparatna,* whose author has borrowed heavily from it. The *Kāmikāgama* the most famous *śaivāgama* text devotes its first part (*pūrvakāmikāgama*) mainly to architecture and one could see many common verses, and sometimes even entire passages, which are to be found in the *Mayamata*. However it is difficult to find evidence of the direction of borrowing.

One could very well include this text in the *aivasiddhZnta* texts as it gives a leading place to the iva temples and because of the speculations on the nature of the *Li ga* which it contains and the pantheon described in chapter 36 of the text. The text stands as a rare and fairly good example of a mediaeval technical text, which could be used as a reference work on Indian architecture of its period and place.

Īśānagurudevapaddhati (ĪGP)

The *ĪGP* also known as *Tantrapaddhati* is an elaborate treatise dealing with different aspects of *Tantra,* including the construction of the temple and related matters, by Īśānagurudeva (11th A. D.)[9]. The work consists of nearly 18000 stanzas in various meters and distributed into a total of 119 *paṭalas* of varying length.[10] The work is divided into four parts namely (i) *Sāmānyapāda* (ii) *Mantrapāda* (iii) *Kriyāpāda* and (iv) *Yogapāda*. The subject dealt with include the hymns on the various deities; *Japa*; *Homa* and other religious rites to be carried out to please them and derive benefits; the means of their attainment; their application for averting the evil effects of poison; malicious plants and diseases; the use of medicines; the properties of medicinal herbs; the science of magic; the construction of temples; consecrations of idols; modes of worship; details of festivals and other allied topics.[11]

In the *Kriyāpāda paṭalas* 23rd to 43 deal with the construction of the temple and idols. This includes the selection of the land, the orientation (*dikpariccheda*), the measurements, the location of the temple, *vāstupūjā*, the description and enumeration of the residences

of gods and men, the classification of the temples, description of the different parts of the temple, the materials for the construction of temples and palaces, selection of the architect, renovation, different types of idols and their measurements etc.

It has been argued by several scholars[12] that the Īśānagurudeva belongs to Kerala on the ground that the occurrence of the word '*timila*'[13] and its reference to the Nārāyaṇīya[14] and *Prayogamañjarī*. It could be added here that the enormous quotations and the references given from *Mayamata* make the view stronger. It is to be noted that many of the early *Śaivasiddhāntas* (upto 1157 A.D., the floruit of Aghoraśiva) when they quote a Maya, they refer not to the *Mayamata* but to a different treatise called the *Mayasaṅgraha*. *ĪGP*, however, while it quotes several *saiddhāntikas* in different parts of the text refers to the *Mayamata* and not the *Mayasa graha* as in other *śaivasiddhānta* texts of other parts of India. So if we could agree the authorship of *Mayamata* to a Keralite as N. P. Unni states, The *Mayamata* attributed to Maya, the celestial architect was popular in Kerala and formed a source book on architecture for many Kerala writers like Nīlakaṇṭha the author of *Manuṣyālayacandrikā*. It is possible that some Kerala authors might have composed the work ascribing it to the celestial architect,[15] then this provides one more argument for assuring the *ĪGP* to have been written in Kerala.

It is very much needed a critical edition of this text[16] and its translation to enable one to know more about the Kerala *Tantra* school.

Tantrasamuccaya[17]

Nārāyaṇa (born A. D. 1428),[18] a Namboodiri brahmin of the Cennās family in Kerala, and who flourished as one of the 'eighteen and a half' (*patineṭṭarakkavikaḷ*) poets in the court of the Zamorins of Calicut during the fifteenth century, is the author of this work on Kerala *Tantra*. The *Tantrasamuccaya*, an elaborate treatise in twelve *paṭalas*, is a standard work on temple architecture and worship, widely popular in Kerala. It deals with the rituals connected with seven important deities, viz. Viṣṇu, Śiva, Śankaranārāyaṇa, Durgā, Subramaṇya,

Gaṇapaṭi and Śāstā. The subjects related to architecture are given in *paṭalas* one (the selection of the site for the construction of the temple, *vāstubali*, the depositing ceremony of the *Nidhikalaśa*, laying of the bricks, the placing of the foundation stones and the selection of suitable granite for the construction), *paṭala* two (characteristics of the temple, its measurements, the details of the construction, the characteristics of the idol and its seat, types of idols and its measurements, *balipiṭhas* - the oblation stones and the measurements of the five fold fortifications), *paṭala* three (purification of the site, sowing of the seeds in the site to test its fertility, preparation of the idol etc.) and *paṭala* six (the installation of the *Mahābalipīṭha* and the flag staff).

There are two commentaries on this treatise, viz. the *Vimarśinī* of Śankara and the *Vivaraṇa* of Nārāyaṇaśiṣya.

The study by N. V. Mallayya *Studies in Sanskrit Texts on Temple Architecture with special reference to the Tantrasamuccaya* (Annamalai University, 1949) is noteworthy here. In the first part of his study the author gives a general introduction to the subject of Indian architecture. Part two contains the stanzas from the *TS* bearing on temple architecture with a rendering in English. Part three gives the critical and expository notes and discussions on the subject of architecture and the interpretations of architectural terminology.

Devālayacandrikā

Nārāyaṇa (1428 A. D), of the Cennās family in Kerala, is well known by his master work the *Tantrasamuccaya*. His one more work the *Manuṣyālayacandrikā* on the construction of human residences also is well known. But there is a third one too ascribed to him named the *Devālauacandrikā*. As in the the case of *Manuṣyālayacandrikā*, the author does not give any details about him in the work. The work should be assigned to him on the basis of the evidences available in the detailed Malayalam commentary on the text.[19]

Manuscripts of the text are yet to be discovered. The above-mentioned commentary contains a few verses of the text and also several verses can be identified by the introductory sentence prefixed to its

commentary. The subject dealt with in the *Devālauacandrikā* is the construction of temples and images of gods for worship. After the introductory verse, instructions are given for the selection of a proper site for the temple (vv. 2-6). The selected spot is then measured and consecrated (7-9). Detailed instructions follow for the actual building (10ff.) The outer walls, pillars, sanctum sanctorum, drain, doorways, decorations on the walls, etc., roofing, spires, halls, etc. are dealt with one after the other. The manuscript ends abruptly with verse 171, the last subject treated being the *śivaliṅga*.[20] Credit goes to K. V. Sarma, who brought out this information towards the scholars through his article *The Devālayacandrikā* published in the *Adyar Library Bulletin* (vol. 25, 1961, pp. 582-586).

Manuṣyālayacandrikā of Cennās

Nārāyaṇa, the author of *Tantrasamuccaya*, has written this text on domestic architecture. It is also known as *Mānavavāstulakṣaṇam*. An a nonymous commentator[21] of this work explains that the author has composed this text extracting appropriate verses from his *Tantrasamuccaya* and adding forty-four fresh verses to suit the subject treated. In the work itself, the *Tantrasamuccaya* verses are incorporated as an integral portion and not as extraneous quotations.

Some of the topics dealt with in this text[22] are the qualifications of the land, orientation, *vīthīkalpana, vāstumaṇḍala, gṛhalakṣaṇa,* the height of the buildings, measurements, different types of dwellings, the special features of the palace etc. As a work of a great author of Kerala, the work needs to be critically edited and translated.

Manuṣyalayacandrikā of Nīlakaṇṭha [23]

This is a well-known work written by *Nīlakaṇṭha* of Tiruma gala, who flourished after the period of the *Tantrasamuccaya*, ie. after the early 15th century A. D. The work is used as a reference manual by traditional carpenters of Kerala. There are seven chapters in this text and each chapter contains twenty to fifty verses in different metres, altogether 225 verses. In verses seven and eight of the first chapter he lists a number of texts he had consulted to compile his work.[24] Among

these he uses the term *Mayamatayugalam*. As Ullūr says 'even though the author mentions two *Mayamatas*, only one *Mayamata* is known to us'. I would like to bring your attention towards a work called *Mayasaṅgraha* in this regard.

The *Mayasaṅgraha*[25] (sometimes simply the Maya, e.g. *Tantrālokaviveka* ad 28:151-6b) is to be distinguished from the published *Mayamata*. From the opening prose of the commentary it is evident that it is a tantric work in which the same Maya, architect of the asuras, instructs sages in what he was himself taught by *Svayambhū*, on the top of the Himavat mountain. Sanderson of the Oxford University has been able to identify a number of early quotations of the work in the sole surviving incomplete palm-leaf manuscript of the *Mayasaṅgraha* in Kathmandu (National Archives of Kathmandu, Ms No.1-1537). Maya is cited as an authority by *Nārāyaṇakaṇṭha* in the *Mṛgendravṛtti* on the *Kriyāpāda* (pp. 31, 69, 74, 81 etc.).; by Kṣemarāja ad *Stavacintāmaṇi* (87, p.96); by Jayaratha in the *Tantrālokaviveka* (ad 8:32c-35b); by Bhaṭṭotpala (ad *Bṛhatsaṃhitā* 52:41); by Hemādri in the *Vratakhaṇḍa* of his *Caturvargacintāmaṇi* (Vol.II, Part I, p. 138); and by Somaśambhu (Karmakāṇḍaramāvalī 1278-1299). References in the *ĪGP*, however are to the later *Mayamata*. It is likely that Nīlakaṇṭha may have been referring this ancient work on architecture.

MC deals with the boundaries of a compound, the site for house building, the length and breadth of a house, different types of halls, the courtyard, the height of the basement, the pillars, the rafters, the underground cellar, cowsheds, the bath room, the kitchen, the rest house all these are discussed in great detail. The methods of fixing rafters, arranging tiles on the roofing, placing door frames and window frames, are among other matters dealt with briefly and clearly. Expositions on the village, town and city testify to the deep knowledge and wide experience of the author.

MC also contains the directions regarding the base to be made for the pillar to rest upon. It could be either in granite or in wood and be a square, a circle, or one with 8 or even 16 facets. One shape in which

it could be made is that of the petals of the lotus flower. It should necessarily be built on the floor of the house. Planting the pillar on the base, the girth and height on the pillars, their salient features, methods for ornamentation - all these are minutely described in the relevant portion of the treatise.

It gives expositions of the methods of constructing houses and their annexes succinctly and clearly. In the passage on land suitable for house building he specifies some trees, the planting of which are believed to bring fortune and misfortune to the family.

The work concludes with a benediction to the house builder with the words 'may he live long and happily in his new home!'[26]

Like other texts on this subject, *MC* too contains valuable information on measurements. One example is the *Aṅgula* which, in *MC* is as follows:

Width of 8 seeds of sesamum plant	*= 1 yavodaram*
8 yavodaram	= 1 mātrāṅgula
12 mātrāṅgula	= 1 vitasti
2 vitasti	=1 karam (or kiṣku or aratni or bhujam or doss or muṣṭi)
25 mātrāṅgula	=kol known as prājāpatya
26 mātrāṅgula	= kol known as dhanurmuṣṭika
27 mātrāṅgula	=kol known as dhanurgṛha
28 mātrāṅgula	=kol known as prācya
29 mātrāṅgula	=kol known as vaideha
30 mātrāṅgula	= kol known as vaipulya
31 mātrāṅgula	*= kol known as prakīrṇa*

It follows that there are 8 different varieties of *kol*, each having its specific length depending on the number of *Mātrāṅgulas* constituting it.

The following Malayalam commentaries by Vilvaṭṭatt Śrī Rāghavan

Nambyār, Pāloḷi Śrī Coyi Vaidyan, Śrī Nīlakanṭhan Ācāri, Śrī Kūnezhatt Parameśvaran etc. are worth mentioning. With its all features it is one of the most authoritative works on Kerala architecture.

Vāstuvidyā[27]

The *Vāstuvidyā, a* Kerala work on household architecture by an anonymous author was published for the first time by T. Gaṇapati Sastri in the TSS in 1913. "Though indebted to *Mayamata* in a noticeable manner and to *Mānasāra* in a lesser extent the *Vāstuvidyā* has all the ingredients of an original treatise in that it is a practical manual put into use by generations of artisans engaged in house building activities."[28] The text is divided into 16 chapters, in 557 verses with a general picture of architecture with special reference to Kerala. Some of the topics dealt with in this text are measures, qualifications of the professionals required for the construction, characteristics of the land, orientation, doors, *Vāstumaṇḍala*, gateway, description of the courtyard and its measurements, auspicious months to start the construction, eight building houses, *pādamāna* definition and measurement, width, length and thickness of median rafter, construction of wall and allied matters, tiles etc. The making of the eleven varieties of tiles mentioned in this text needs special attention since it is perhaps for the first time the subject is treated by a Kerala author.

Śilparatna of Śrīkumāra[29]

Śilparatna is an encyclopedic work by a Keralite scholar on the subject of *Śilpaśāstra*. The author of this text Śrīkumāra, son of Rāma, and who belongs to the bhārgavagotra was one of the poets in the court of Cembakaśśeri Pūrāḍam Tirunāl and it is said that he had written the work as per the instruction of the above mentioned king. The text contains two parts, the *pūrvabhāga* and *uttarabhāga*, with 46 chapters and 35 chapters respectively. While the first part deals with the construction of houses, villages and other allied subjects the second part deals with the iconography and kindred topics. In the end of the *pūrvabhāga* the author mentions that he had written about the construction of the city, temple and houses (*nānāgrāmādi-*

devālayanarabhavanādy uktalakṣmaprakāśam, Silparatna, I.46.248).

The *Śilparatnam bhāṣā*[30] (also known as *aṭukku* and *Taikkāṭṭubhāṣā*) of a Namoodiri brāhmin of Taikkāṭṭillam is a well known maṇipravāḷam version of the *Śilparatna*, which is familiar among the traditional carpenters of Kerala.

Apart from the above mentioned major Sanskirt works there are several other less known texts on this topic produced in Kerala. K. V. Sarma's *Science texts in Sanskrit in the manuscripts repositories of Kerala and Tamilnadu* (Rashtriya Sanskrit Sansthan, New Delhi, 2002. pp. 207-215.) mentions nearly two hundred Sanskrit texts on architecture available in the different manuscript libraries of Kerala and Tamilnadu. It is worth to note that among the two hundred texts indicated only ten texts are so far edited.

Malayalam works

As we had seen above while the literature in Sanskrit on architecture produced from Kerala is vast, there is still a considerable amount of work written in the regional language Malayalam and in Maṇipravālam. While there are several commentaries and translations in Malayalam available for several Sanskrit works on the subject, the independent work, on the subject too needs special attention. We shall look into some of the modern works, prepared for the benefit of the general reader, in the last few decades.

Gṛhanimāṇapaddhati is written by Parakkal Krishna Warrier with a view to enabling the layman to have a glimpse of Kerala's great architectural heritage. This book is a welcome addition to the literature on architecture. The sketches and plans included wherever necessary are extremely useful to the reader.

Keṭṭiṭaṅgal by the noted authority on the Kerala *Tantra* and architecture Kanippayyur Sankaran Namboodiripad is an attempt to combine as far as possible and practicable, old concepts with new trends, resulting in improvisations marked by freshness and a new vitality. Included in *Keṭṭiṭaṅgal* are 77 ground plans of different types

of buildings conceived and prepared by the author himself. The methods of constructing foundations and walls, making doors and windows and ceilings and roofs, ensuring free air and light, beautifying the interior, are all discussed in a simple but authoritative manner. The author has taken care to acquaint his readers with various notions and beliefs that had become part and parcel of Kerala architecture in the past.

Gṛhacitrāvali (Śilpaśāstram), Vāstukaumudi, Śilparatna samuccayam and *Śilpibāla-prabodhinī* by Taṇṇīrmukkam V.K. Vāsu Ācāri (Vidyarambham Publications, Allapuzha); *Gaṇitaratnākaram* (*Śilpabhāgam- Kaikkaṇakku*) and *Bālārāmam* by Payyannūr N. Keśavācāri (Vidyarambham Publications, Allapuzha) etc. are some of the titles available in this filed.

Edition and translation of technical texts

In editing science texts one may encounter certain peculiar difficulties such as the question of technical terms contained in the text. The editors of the scientific texts should give more attention towards the technical part of the text, and it will not be enough if the editor just tries to establish the text as written by the author. To help a modern student of the subject, the edition should contain a translation, there too wherever necessary he should give necessary notes, explanations, elucidation's, and if possible with figures and pictures.

Analysis or translation of texts dealing with architecture poses from the start a twofold vocabulary problem: defining the terms and translating them. One could retain the Sanskrit term itself but this approach is not always desirable to scholars, especially for those who want to compare the same with modern aspects.

The technical texts employ (of course other literature too) rather a large number of terms to designate a single element. As we could assume the exigencies of prosody generate such usages. So a simple and easy method should be adopted to translate these terms. Perhaps one could use a single particular English term in the translation even though the

term is indicated with different synonyms. Then a complete glossary of terms with their equivalents rendered in the translation could be appended to the edition, so that the reader will not have difficulty to follow the text, and in the meantime he will have access to all the technical terms used in the text.

Now, it may be worth mentioning some of tools for translating these technical texts, such as dictionaries in the subject. As we know, the specialized vocabulary of Sanskrit architectural treatises is rarely quoted in classical dictionaries. The effort of Ram Raz should here be mentioned, who provided an initial collection of definitions, a number of which may be considered as definitive, particularly those referring to moldings, in his *Essay on the Architecture of the Hindus* (Indological Book House, Delhi, 1834.). The revised (by P. K. Gode and C. G. Kharve) *Sanskrit-English Dictionary* by V. S. Apte contains a number of definitions on the subject. *An Encyclopedic Dictionary of Sanskrit on Historical Principles* being published by the Deccan College post-graduate and research institute, Poona, too takes the terms on this topic some extent. The Encyclopedia of Hindu Architecture (1946) by P. K. Acharya becomes a basic reference work, as it contains a very large vocabulary from technical literature, as well as from epigraphical and classical texts. The contribution of scholars such as A. K. Coomaraswamy (Indian Architectural Terms , *JOAS*, Vol. 48, 1928, pp. 250-275), N. V. Mallaya (*Studies in Sanskrit Texts on Temple Architecture*, 1949), L. K. Sukla (*A study of Hindu Art and Architecture with special reference to terminology*, Varanasi, 1972.), Stella Kramrish[31] etc. are to be referred in this regard. An important article by K. G. Krishnan, 'Architectural Terms in South Indian Inscriptions' (in *Studies in Indian Temple Architecture*, 1975) contains the first systematic survey of Sanskrit and Tamil architectural vocabulary as employed in inscriptions.

In his preface to the edition of the *Manuṣyalayācandrikā* (TSS 56) T. Ganapati Sastri says: "There are throughout this work, many technical expressions peculiar to architecture. I hope to publish a vocabulary of all such terms occurring in this work as well as in the *Mayamata*,

Silparatna and other works"[32]. But unfortunately the above mentioned vocabulary has not seen the light. It is necessary that a vocabulary of the technical terms occurring in the texts written in Kerala dealing with architecture should be made available to enable students who want to enter in this field of research.

The question of technical terms in translations requires some consideration. In his introduction to *the Architecture in the Ajitāgama and the Rauravāgama*[33] Bruno Dagens observes that a number of archaeologists use purely Sanskrit nomenclature in describing monuments. Such a procedure is only justified if the terms used are clearly and correctly defined, which has not always been the case. A well known example of incorrect usage is the term vimāna, which is used by most authors to designate the upper portion of a temple, when, in fact, it actually applies to the temple as a whole. As far as South Indian architecture is concerned, one of the few authors who seem to have used this approach properly is H. Sarkar, a reliable expert on monuments and texts who has written a monograph which, though brief, is a model of its kind, *The Kampaharesvara Temple at Tribhuvanam* (1974)."[34]

When one is working with the texts produced in a particular region, or if one is going through a commentary written for the benefit of local people then it is likely to find technical terms in the vernacular. This is especially true of works dealing with Kerala architecture. Some such terms occurring in different works and commentaries on them is given below, to show their nature.

Terms in Sanskrit	Their description
Dikpariccheda	determination of the cardinal points
śaṅku	gnomon; the pin of a dial whose shadow points to the hour; an upright rod for taking the sun's attitude by its shadow.
sthānabhūmi	assembly hall

garbhabhūmi	cellar; a niche underneath a floor
daivikyāvṛti	(twelve squares in the) first enclosure next to the place assigned to the brahman
āvṛti	enclosure in general
marma	crossing of lines
śira	diagonal lines in sixty four squares
vaṃśa	the horizontal and vertical lines in sixty four squares
bhinnaśālā	a house in which the rooms have their own yoni, width and *gamana* and stand at four cardinal points and corners.
catuśāla	a house, having one yoni for the rooms in four cardinal points and the four corner points and also for the perimeter.
ekaśāla	a house where the rooms at cardinal points have their own yoni and the perimeter has the first yoni.

Terms in Sanskrit	Terms in Malayalam	Description in English
Takṣaka	*cettupaṇikkāran*	one who cuts to size
Lambakam	*tūkkukaṭṭa*	the suspended weight
Dvāram	*paṭipura*	gateway to the house
anyanīyam	*kiṭappura*	bedroom
annabhūmi	*ūṭṭupura*	the place for feeding people
garbhabhūmi	*nilavara*	the underground chamber
aṅkaṇam	*naṭumuttam*	the quadrangle
sandhi	*iyappu*	joint *nīrvalambam* also
nīvarapaṭṭi	*vāmaṭa*	a particular rafter
valaya	*vaḷa*	corner rafters
kūṭasandhānam	*mōntāyam*	joint of the rafters
paraśu	*vāyika*	axe

Conclusion

The need to bring all of the works on Kerala architecture to light and publish them for the benefit of students of architecture is very much required. Valuable manuscripts might have been already lost for ever in this field of study. However, it is highly probable that intensive research might unearth at least a few which have survived destruction. It will be of great benefit if editions of such texts pertaining to this field, especially the unpublished ones, are published along with their translations and available commentaries. When all this is done, a substantial body of literature on Kerala architecture will be available. A detailed history of the texts on Kerala architecture is lacking at present.

References

1 *Mayamata*, V. 13-25; *Vāstuvidyā,* I. 12-21.

2 These schools of Kerala artisans are mentioned in an old commentary on *Vāstuvidyā,* ed. By V. Chandrasekharan Pillai and S. Balakrishnan Asari, Oriental Research Institute and Manuscripts Library, University of Kerala, Trivandrum, 1978.

3 Ed. by K. Raman Nampiyar with K. Acyutapotuval, Tripunithura, 1953-54.; A critical edition of this text with its commentary *Pradyota* is under preparation by Prof. N. V. P. Unithiri and S. A. S. Sarma

4 N. P. Unni, *Introduction to Tantrasamuccaya*, p. 23, *Kerala Sahitya Caritram*, I, p. 200.; See also: E. V. Raman Namboodiri, Introduction to *Tantrasamuccaya*, pp. 84-85, Oriental Research Institute and Manuscripts Library, Trivandrum.

5 Ed. By T. Ganapati Sastri, Trivandrum Sanskrit Series (TSS) 65, Trivandrum, 1919; ed. with Tamil translation by K. S. Subramanya

Sastri, 2 Vols., Tanjore Sarasvati Mahal Series 113, 1965-1968; Critically ed. with French translation by Bruno Dagens, 2 Vols., Pondicherry 1970; and later the same translation in English version published from the Sitaram Institute of Scientific Research, Delhi, 1985.

6 Many earlier works treat architectural themes. Eg. Kiraṇatantra, Mayasaṇgraha, *Mohacūdottara, Somaśambhu,* various works of Varāhamihira etc.

7 Dagens, *Mayamata*, p. ii.

8 Dagens, *Mayamata*, p. v.

9 According to N. P. Unni, A general introduction to *TS*, p. 1.

10 See the introduction by N. P. Unni in the reprinted edition of *ĪGP*, Ed. T. Ganapati Sastri, published by the Bharatiya Vidya Prakasan; *Īśānagurudevapaddhati* (in 4 vols.,) Delhi, pp. 1-126. First published in the TSS Nos. 69, 72, 77 and 83, Trivandrum, 1920, 1921, 1922 and 1925.

11 N. P. Unni, *ĪGP*, p. 26

12 N. P. Unni, *ĪGP*, Vol. I, pp. 12-13; *KSC*, Vol. I, p. 202.

13 *saṅgītanṛttavāditraih Śaṅkhakāhaḷagomukhaih/ timilānakabheryādairninadadbhiranāratam// ĪGP*, 50.343; T. V. Gopal Iyer of the French Institute, Pondicherry informs me that the word *timila* could be seen in the Tamil literature too. Ex. A list of drums are given in the commentary of Aḍiyarkkunallār on *Śilappatikāram*, 3.27, in which the *timila* also is included.

14 Published under the title *Tantrasārasaṅgraha*, ed. with commentary, Madras Government Oriental Series, No. 15, Madras, 1950.; See also: *Tantrasārasaṅgraha* of Nārāyaṇa with the commentary *Mantravimarśinī* by Svarṇagrāma Vāsudeva. ed. N.V.P. Unithiri, Calicut University Sanskrit Series 15 & 16, Publication Division, University of Calicut, 2002.

15 Introudction to *Tantrasamuccaya*, p. 30.

16 In the available edition there are several passages left out, with +

marks. Ex. Vol. II, p. 352, Vol. III, p. 71; Vol. IV, p. 458; see also the corrupt quotations therein from Rāmakaṇṭha's *Kiraṇavṛtti* quoted in the apparatus of the Dominic Goodall's critical edition of that text on pp. 12, 14. French Institute, Pondicherry, 1998.

17 Ed. T. Ganapati Sastri (TSS), Reprint with Introduction by N. P. Unni, Nag Publihsers, Delhi, 1990.

18 N. P. Unni, Introduction to the *TS*, p. 34.

19 Mal. D. 245 of the Govt. Oriental Manuscripts Library, Madras. This is a transcript prepared in 1917-18 from an old palm-leaf manuscript belonging to Ampalakkāṭṭu Menon, Chalappuram, Calicut.

The introductory verses of both *Manuṣyālayacandrikā* and *Devālayacandrikā* are the same with regard to the first three lines. While the fourth line in the Manuṣyālayacandrikā reads '*samāsato mānavavāstulakṣaṇam*' the *Devālayacandrikā* reads '*samāsya devāyatanādi-lakṣṇam*'.

20 K. V. Sarma, 'The *Devālayacandrikā*', *Adyar Library Bulletin* (1961), 25, p. 583.

21 Ms. No. Co. 311, *Descriptive Catalogue of Skt. Mss. in the Curator's Office*, Trivandrum, VI, pp. 2443-44; the commentator states thus; *ayaü kaviḥ 'mayā tantrasamuccaye devālayalakṣaṇaü uktam. Manuṣyālayalakṣaṇaü kutrāpi noktaü ca; tasmād idānīü Tantrasamuccayāt katipayapadyāni yathāvakāśaü uddhṛtya, taiḥ saha catuś catvāriüśadbhiḥ ślokaiḥ Manuṣyālayalakṣaṇaü vakṣyati [vakṣyāmi]' iti niścitya tatrādau prathamena ślokena iṣṭadevatānamaskāraü cikīrṣitapratijúāü cāha - 'praṇamya viśvasthapatiü pitāmaham'* iti.

22 The work with an old commentary, ed. by S. K. Ramanatha Sastri is published in the Madras Government Oriental Manuscripts Library Series XXI, 1950. This editor presumes that the original text must be the one composed by Nīlakaṇṭhan Mūssatu, though he is not certain with this view.

23 *Manuṣyālayacandrikā*, ed. by T. Ganapati Sastri, TSS 56, 1917.;

with Malayalam commentary, ed. by Kanippayyur Sankaran Namboodiri, Kunnankulam, 1965.

24 *Mayamatayugaḷaü prayogamañja-*
ryapi ca nibandhānabhaskarīyayugmam /
manumatagurudevapaddhatiśrī
hariyajanādimahāgamā jayanti /
mārkaṇḍeyayugaü parāśaramurāriproktaratnāvalī-
sārān kāśyapaviśvakarmamatayugmādyam kumārāgamam /
savyākhyāü harisaühitām vivaraṇākhyāü vāstuvidyādikān
dṛṣṭvā tantrasamuccayoktamanusṛtyaivātra saükṣipyate /
Manuṣyālayacandrikā I. 7-8.

25 For a short description of this text see: Dominic Goodall, *Kiraṇavṛtti*, Vol. I, French Institute, Pondicherry, 1977, pp. x-xi.

26 *svīyaiḥ sārdhaṃ, svagehe suciram adhivaset pūrṇakāmaiḥ sukhena, MC*, VII. 37.

27 I am thankful to V. Lalitha who was kind enough to provide her thesis *Vāstuvidyā - A study on Kerala architecture,* submitted to the University of Kerala, 1993, to enable me to know much about this work.

28 V. Lalitha, p. ii

29 Ed. T. Ganapati Sastri, TSS 75, 1922.; See also, N. V. P. Unithiri, Śilparatna in this book.

30 KSC, II, p. 398.

31 *The Hindu Temple*, University of Calcutta, 1946.

32 T. Ganapati Sastri, *MC*, p. i

33 Sitaram Bharatiya Institute of Scientific Research, New Delhi, 1984.

34 Bruno Dagens, *The Architecture in the Ajitāgama and the Rauravāgama*, pp. 9-10.



Iconography and Sculpture

Balagopal T.S. Prabhu

On the (vertical) fire lines upright forms are produced. On the (horizontal) water lines forms expressing feelings are produced. On the (diagonal) wind lines fiery (energetic) forms are produced. The knowledge of the line is then to be known as all comprehensive in sculpture. (*Vāstusūtropaniṣad*, 2.23-26)

1. Introduction

Sculpture (śilpa) is an integral part of traditional Indian architecture, indeed the design principles of both arise from same theory. In traditional Indian architecture, the sculptural art and structural engineering are so synthesised that the separation of the art and engineering is impossible. Here the structural form is modified by sculpture beyond recognition, and simultaneously sculptural form is made out of structure. The moulding of the base, the treatment of the pillars, the decoration of the wall, the forming of the roof are all done in a manner by which the harshness of stone and timber is relieved by the smoothness of the sculpture. The building elements such as door frames, sides of wall openings, beams and rafters, ceiling joist and planks, dormer windows, steps and hand rails,water spout etc, are all artistically moulded or carved in delicate proportions. The common

motifs of sculptural treatment were geometrical patterns, flowers, animal life, human forms, gods, demigods and grotesque figures of wild imaginations. The sculptural work is done in half relief as well as in full rounded form. There is strictly no separation or distinction between religious and secular art in India. Consequently in all buildings one may see sculptural works in which gods, demigods or human beings are shown in all forms, shapes and postures. They are carved or moulded expressing nine basic emotions - śṛṅgāra (erotic), karuṇa (pathetic), vīra (heroic), raudra (furious), hāsya (laugh exciting), bhayānaka (fearful), bībhatsa (loathsome), adbhuta (wonder evoking) and śānta (peaceful) together with preyas (loving) and pratīkṣā (expecting), with subtle changes of lips, eyes, eyebrows and postures.

Two types of sculptural works may however be clearly distinguished in the land. One belongs to the category of sacred art, concerned with the representations of gods as objects of worship installed in shrines. The second type, more numerous, includes all works in which gods, demigods, kings, sages and ordinary people are represented on every surface, niches, panels or elements as decorative treatment. Here are events from epics, legends and classics as well as from day to day life as preceived by the craftsmen. The form, style and expression of the secular art are flexible. The craftsmen are free to incorporate local traditions or humorous depiction of events. However, the canonical rules of dimensions, proportions and details of the images of gods for worship as laid down in Āgamic texts and they are irrefutable and unchangeable. This dual approach has helped to achieve uniformity and unity in the spiritual aspect of the sculpture, and to permit diversity and variety in the mundane aspect of art depending on characteristics of climate, dress, ornaments, social customs etc. of different geographical and ethnic regions of India. Outwardly, one is confronted with a panorama of regional artforms in sculpture, but they all merge into a unified expression in the images of Gods.

II. Materials for Making Images of Gods

According to Āgamic texts, the images of gods may be made in

six types of materials - jewels, metals, stones, earth, wood or glass.

1. Jewels: The nine jewels associated with the astrological planets are listed below. Gods worshipped in jewels are believed to bestow all wishes (sarvakāmaphalaprada), according to *Padmasamhitā*. Of the jewels māṇikyam (ruby) is the most important material for making images of god. The Bharata image of Irinjalakuda is believed to be ruby.

Planets and Associated Jewels

Gṛha			
Sūrya	(Sun)	māṇikya	(Ruby)
Candra	(Moon)	mauktika	(Pearl)
Kuja	(Mars)	vidruma (pavizham)	(Coral)
Budha	(Mercury)	marataka	(Emerald)
Guru	(Jupiter)	puṣyarāga	(Topaz)
Śukra	(Venus)	vajra	(Diamond)
Śani	(Saturn)	indranīla	(Saphire)
Rāhu		gomedaka	(Chinnamon)
Ketu		vaidūrya	Cat eye

2. Metals : Eight types of metals used for making images of gods and their beneficial aspects or malefic effects are listed in the table below:

Nature	Name of metal	Effects of worshipping gods with images made of metals
Benefic (Śubha)	Gold (sauvarṇa)	Peace and salvation
	Silver (rājata)	Prosperity
	Copper (tāmraja) (Putradam)	Prosterity-lineage
	Brass (paittala)	Education
	Bronze (kāsya)	Health and long life

Malefic (Aśubha)	Iron (āyasa)	Malefic used for magical rites
	Lead (saisaka)	Related with depiction of demons
	Tin (trāpuṣa)	

3. Stones: Stones for making images are basically classified into four types depending on their colours. White, reddish, yellowish and blackish, each prescribed as suitable for Brāhmaṇas, Kṣatriyas, Vaiśyas and Śūdras respectively. They are also said to bestow salvation, victory, riteness and grains respectively to the worshippers. The stone should be of uniform colour, should be dense, smooth and deeply embedded in earth. It should be of appropriate dimension and free from defects such as spots, streks, flaws, faults and cracks. Depending on the shape and workability, they are further classified into three types - male, female and neuter. A stone is said to be male when it is of uniform colour, dense, smooth and perfectly cylindrical. When struck by hammer it gives the sound of an elephant bell. A female stone has a wide bottom and narrow head and produces the sound of a cymbal when struck by a tool. A neuter stone is bulged at the middle and produces no sound when struck by tools. Stones are by far the most common material for making images of god for installation in temples. The male types of stone is generally prescribed for making idols. Female types of stones may however be used for making images of goddesses and in all cases for making pedestals on which the idols are moulded. The neutral stones are used only for base course of the pedestal (pādaśilā)

4. Wood : Twelve trees are prescribed for making wooden images of gods as listed below, which are appropriate to each varṇa as they are supposed to blow the effects due to each.

1. Candana, devadāru, śamī	Brāhmaṇa (salvation)
2. Pippala, śimśapa, khadira	Kṣatriya (victory)
3. Asana, mālūra, madhuka	Vaiśya
4. Bakula, padmaka, karṇikāra	Śūdra (grains)

Bhagavatī image at Cranganure, Pārvatī image at Vaṭakkunnāthan temple at Trichur, the idols of Kṛṣṇa, Balarāma and Subhadrā at Puri etc. are examples of wooden images.

5. Earth : Images made of earth have a special significance in Indian iconography. Lord Rama worshipped Śiva by making an earthern liṅga at Rameswaram before launching his war with Rāvaṇa. Arjuna also made an earthern liṅga and worshipped Śiva when faced with defeat from Kirāta, who was none other than Śiva in disguise. The system of making earthen liṅga is very common in all places for offering worhip to Śiva at Tīrthas, on occasions such as Śivarātri. Good quality earth, specially processed, is used to mould images in its raw form or baked form. This is called mṛṇmayabimba (earthern image).

A special method of preparing god images in composite materials, with earth as the basic ingredient is called miśrakabimba (composite image) also called bahuverabimba. The composite image making is a complex process. The bones are simulated in sticks of selected trees and tied in positions by copper strings. It is covered with adhesives over which fibres to represent nervous system are fixed. The frame work is then pasted over and over with a composite matrix made by inter grinding earth with grains, spices, medicinal essences, milk, ghee, powered jewels, holy water etc. to beautifully shape the image. The whole is then covered in the silk and coated finally with a hard enduring resinous composite, made as above, chiselling life like features on the image. It may be then painted in appropriate colours to complete the process. A variety of auspicious and precious materials go into the image making process, lasting long period of ritualistic penance in such bahuvera images. The Anantapadmanābhasvāmī image at Trivandrum is an example of such an image.

6. Glass: Sphaṭika (glass) is a rare category of material for making gods' images. It has three categories - spaṭika (glassy crystal), sūryakānta (crystal of sun's lusture) and candrakānta (crystal of moon's luminance). The worship of god in the spaṭika images is believed to bestow health, wealth and prosperity in this life and salvation after death.

III. Symbolic Representations of God

There are three sorts of representation of gods - symbolic, iconic and mixed. The symbolic representation is known as niṣkala or liṅga. The iconic images are called sakala or bimba. The mukhaliṅga is a combination of these two - iconic images super imposed on a liṅga and is called in miśra category of image.

According to Āgamic text the manifestations of god in the form of a diety represents only certain specific aspects of the universal form of god - Brahma. The three traditional divisions of the ultimate reality are Brahmā, Viṣṇu and Rudra representing the creative, preservative and destructive (sṛṣṭi, sthiti and samhāra) aspects. They get manifested in many forms with the power (śakti) conceived as ever associated with the ultimate reality. The symbolic representations of these dieties are done in a single stone divided into three equal parts. The lowest part, square in sections, represents Brahmā, the middle octagonal section, Viṣṇu, and the top circular portion Rudra. As the symbolic stone is mounted on a pedestal and firmly set, only the cylindered portions of the stone representations of Rudra is revealed to the onlooker, consequently the symbolic representations of Śiva over the years has been associated with this cylindrical form of liṅga.

The liṅga is fashioned from a square stone brahmaśilā. It is divided into 3 parts. The octagonal section is formed by chiselling of the four corners. Successive removal of the sharp corners converts this octagon into a circular form. The cylindrical portions of the liṅga is rounded at the top and given certain characteristic signs appropriate to the worship of Śiva in different types of temples (nāgara, drāviḍa, vesara etc.) as prescribed in Āgamic texts. Depending on the method of opportunity of the length among the three sections, liṅgas are categorised into 4 types - sarvasama, samāsama, vardhamāna and īśādhika. The sarvasamaliṅga has equal lengths for the square, octagonal and circular sections. The lengths of the section in the samāsama category are equal to the perimeters of the sections. This means that the square sections will have maximum length, the octagonal

sections a medium length, and the circular scetions minimum length. This type of liṅga is, however, rarely adopted for worship. In the vardhamāna liṅga, the lengths of these sections increase by one unit as one moves from the square through octagonal to circular sections. Common ratios of lengths are 4:5:6, 5:6:7, 6:7:8 and 7:8:9. In īśādhika liṅga the length of the lower portions are equal, but that of the upper portions is one module more than that of the lower ones. The common ratios of lengths here are 3:3:4, 5:5:6 and 7:7:8.

The total length of the liṅga is expressed in three ways. Firstly, in absolute measures, the length of the liṅga varies from 1 hasta to 5 hasta, in successive increments of 1/4 hasta or 6 aṅgula. Secondly, it is taken as a ratio of the width of the garbhagṛha. The length of the liṅga may thus be taken as 1/2, 5/9 or 3/5 of the cell width. Thirdly, the length is taken in relation to the height of the door opening into the garbhagṛha. It may be equal to the door height, or with an increase or decrease of quarter this height. In general the width of each portion of the liṅga is related to its length, varying from 5/24 to 8/24 of the length of the sections.

The pedestal for the liṅga consists of square seat with its side length equal to 3 times the diameter of the liṅga and height equal to that of the octagonal portions and a projecting spout of 1/3 of this size. It has an octagonal hole in the centre into which the viṣṇukhaṇḍa of the liṅga gets fixed, with only the cylindrical rudrakhaṇḍa projecting out side. An annular groove around the liṅga for draining the abhiṣeka water is joined to the channel in the projecting portion of the pedestal. This channel is always oriented towards the north with a gentle deflection of 1/16 towards the east. The continuation of this channel outside the garbhagṛha is seen in the form of the highly sculptured form of the spout (praṇāla). The pedestal height is divided into 16 parts and fashioned with moulding.

Depending on the method of treating the visible part of the liṅga above the pedestal, there are many varieties, chief of which are trairāśika liṅga, surārcita liṅga, dhārāliṅga, sahasraliṅga and mukhaliṅga.

Trairāśika liṅga is one in which the total height is divided into 9 equal parts with each of the Brahmā, Viṣṇu and Rudra khaṇḍa taking three equal parts, but the circumferences of the square, octagonal and circular sections are prescribed as 8/9, 7/9 and 6/9 of the total height. The liṅga in which the width is equal to quarter of the height of the section is the type worshipped by gods and hence called surārcita (honoured by god) liṅga. If the worshipped elements of a liṅga is divided into two sections, with the lower portions prescribed with a number of facets (4, 8 or 16) and the upper portion has twice as many, such a faceted liṅga is known as dhārāliṅga. A sahasraliṅga is one which as 25 facets cut on the circular portion, each facet being superposed with forty images of liṅgas.

IV. Mukhaliṅga

The most fascinating symbolic representation of Śiva is in the form of liṅga with faces. The width of this liṅga is 3/10 of its height. The height is divided into 10 equal parts, of which 2 parts from the shoulder, 1 part neck, 3 parts face, 1 part top of the head, 2 parts hair arrangement and 1 part for the top of the liṅga. On the four sides of the liṅga are the perfect sculpturing of the god's head in every minute detail. The face on the east is that of tatpuruṣa, the supreme form of Śiva with three eyes (trinetra), knotted hair (jaṭā) and fish shaped ear rings (makarakuṇḍala). The south face is that of aghora, or Śiva in the form of destroyer, with over locks of hair studded with skulls (kapāla) and with adornment of snakes (nāgabhūṣaṇa). The west face is that of sadyojāta, Śiva in pure and pleasant form, adorned with precious stones. The north face is that of vāmadeva, Śiva in the gentle and lustrous form and decoration appropriate to a young girl. The mukhaliṅga is seen at its best in the cave temple at Elephanta dated 6th century AD.

It may be noted that mukhaliṅga is only one form of iconic representation of Śiva. According to mythology, Śiva has 18 manifestations, classically worshipped in the iconic form.These eighteen forms as given in *Śilparatna* are listed below:

1. Sukhāsana (Śiva comfortably seated)

2. Somāskanda (Śiva with Umā and Skanda)
3. Chandraśekhara (Śiva with moon in his crest)
4. Vṛṣārūḍha (Śiva and Umā mounted on bull)
5. Nṛttamūrti (The dancing Śiva form)
6. Gaṅgādhara (Śiva holding Gaṅgā in his hairs)
7. Tripurāri (Śiva with Umā, the destroyer of tripura)
8. Kalyāṇasundara (Śiva with Umā in all adornment)
9. Ardhanārīśvara (Śiva forming the right of the body and Umā left half)
10. Gajaghna (Śiva stripping the skin of elephant)
11. Paśupati (Śiva as protector of animals)
12. Kaṅkāla (Maheśvara as a hunter, with all ornaments accompanied by Bhūtagaṇa)
13. Śaṅkaranārāyaṇa (Harihara, Śaṅkara forming the right half of the body and Viṣṇu the left half)
14. Bhikṣāṭanamūrti (Śiva in the mendicant robe, in the position of walking)
15. Chaṇḍeśvara (Śiva in the posture of drawing a bow and as bestower of a boon on Caṇḍeśa)
16. Dakṣiṇāmūrti (Śiva in the teaching posture)
17. Kālāri (Śiva as the slayer of Kāla)
18. Liṅgasambhūta (Mukhaliṅga, Śiva in the form of liṅga)

V. Iconic Representation of Gods

The iconic representation of gods involves many considerations such as:

1. The height of the image, 2. The position of posture, 3. The pedestal for mounting the image, 4. The overall proportions of the image with regard to height, 5. The detailed proportions related to the divisions of the parts, 6. Aspects and emotions of the dieties, 7. Attire, garments, ornamentations and accompaniments, and 8. Decorative treatment of aura and enframement. Indian iconography and iconometry is a vast discipline which takes up all these aspects in elaborate detail for the representation of numerous gods and goddesses, sculptured not only as main images of worship, but also as attendant dieties on

the walls, ceilings, dormer windows, pillars etc. The iconographical themes were also extended for general decoration of temples on a profuse level as in Belur, Khajuraho, Konark etc. with mythological and wordly scenes with magnificent imagination as well as with brutal realities.

The overall height of the images of worship are determined from three considerations, namely, (i) the width of garbhagṛha (ii) the height of the door opening and (iii) the height of the founder of the temple. In terms of the width of the garbhagṛha the height is taken as equal to its width or a proportion (2/3, 3/4 or 1/2) of the width. In terms of the height of the door opening the total height of the image may be taken as equal to 1-1/2 H, 1-1/4H, 1H, 3/4H, 2/3H, 2/3 of (7/8H or 8/9). In relation to the body of the founder, the height of the image may be taken as equal to his height, or as high as the shoulders, nipples or navel of the founder. The height of the vertical reference line so opted is to be checked for its astrological auspiciousness before finally accepting the same. The dimension of the portable images are decided as a proportion of the principal image (1/7, 1/6, 1/5, 1/4, 1/3, or 1/2 of the principal image)

The overall heights of the images in standing posture (kautukāyāma) are modified in the case of images in sitting (āsīna) and lying (śayana) postures. For images in sitting posture the height is 2/3 of the dimensions given for the standing images. The height of lying images is similarly 1/3 of the height proposed for standing images. The length of the image in lying posture is however decided by the length of the garbhagṛha. For uttama category of images the length is divided into 16 parts, 4 parts are left at the right end where the head comes, and 2 parts at the left end when the feet are depicted. Alternately the length may be divided into 8 or 7 parts with 2 parts left at the right and 1 part at the left end of the garbhagṛha. It is also recommended that such a garbhagṛha should have a triple doors for viewing the image fully, as provided in Tirupati (Govindarājapattana) and Śrīraṅga.

The pedestal for statues are to be formed befitting the

ornamentations of dieties. The height of pedestal is 1/5 of the height of the image if standing, 1/4 if it is sitting and 1/3 if reclining. For standing and sitting images, the height of the pedestal is divided into 5 portions, the top two portions forming the padmapīṭha and the lower 3 parts its base. The base is square or rectangular in shape and it is to be formed as described in the case of liṅga pedestal. The top element of padmapīṭha may be circular, oval or semicircular in plan. Its width is twice the height. This height is to be divided into 6 equal parts in its simplest form with 1 part each taking the bottom and top string and two moulding of lotuses, a taurius in between. For seated images the width of the pedestal is suitably increased. Depending on the divisions of the height, shape of the plan and details of moulding, there are nine types of pedestals - bhadrapīṭha, padmapīṭha, vajrapīṭha, mahāmbuja, śrīkara, pīṭhapadma, mahāvajra, saumyaka and śrikanya - as described in *Mayamata*. *Silparatna* describes many more with names such as merusundara, lakṣmīsundara, samāṅgabhadra etc.

There will be cases in which more than one diety are installed on the same pedestal. In such a case the most important diety is given the height, as determined above. The height of other dieties are reduced suitably. For example, if the statue of the goddess is also put up along with that of the god, the height of the female image is fixed only as much as the nose or shoulder height of the male image. This difference may be divided into 8 parts and the height of the female diety fixed at any of these values also, according to *Bhāṣāśilparatna.*

VI. Proportions in Iconography

Indian iconography makes use of 10 main varieties of proportions of images ranging from ekatāla (1 tāla) to daśatāla (10 tāla). Tāla literally means palm, the inner length of hand including the fingers, which is stated by the sages as the length of the face. This length is divided into 12 parts or aṅgula, the width of the middle phalax of the mid finger on the right arm referred as nīcāṅgula in the dimensional system. In the proportionate system of iconometry, tāla simply refers to the face length of the image - from the lower cheek to

the top of the forehead which is also taken as the width of the face. One twelth of the tāla is a unit called aṅgula and one eighth of the aṅgula is a subunit called yava. An image is said to be of a particular type, say aṣṭatāla (8 tāla) if the total height of the image from the feet up to the forehead is equal to 8 times the face length. It will thus have 96 aṅgula height.

Each proportion, say aṣṭatāla (8 tāla) is divided into three varieties - uttama (highest), madhyama (middle) and adhama (least). 96 aṅgula is the measure of the madhyama (mean measure) of the category, the uttama highest measure being 4 aṅgula more than the mean, i.e., 100 aṅgula, and the adhama (least) being 4 aṅgula less than the mean (92 aṅgula). While a particular major variety of tālamāna proportions is adopted for a category of images the three subdivisions - uttama, madhyama and adhama - are used to portray the superior, median and inferior dieties of that particular category as shown in the table.

Category of Tālamāna	Sub category	Gods represented
10 tāla (daśatāla)	Uttama 124 A	Brahmā, Viṣṇu, Maheśvara
	Madhyama 120 A	Sarasvatī, Lakṣmī, Umā
	Adhama 116 A	Durgā, Bhūmi and Godesses and sages (Maharṣi)
9 tāla (navatāla)	Uttama 112 A	Aṣṭadikpālaka, Vasu, Gods and Goddesses
	Madhyma 108 A	Yakṣa, Śivagaṇa
	Adhama 104 A	Vidyādhara, Siddha, Gandharva, Pitṛs
8 tāla (aṣṭatāla)	Uttama 100 A	Śreṣṭha
	Madhyama 96 A	Madhyama human beings
	Adhama 92 A	Adhama
7 tāla (saptatāla)		Piśācas (demons)
6 tāla (ṣaḍtāla)		Dwarfs
5 tāla (pañcatāla)	Uttama 64 A	Gaṇeśa, Skanda, Vāmana
	Madhyama 60 A	Bhūtagaṇa of gods
	Adhama 56 A	Childrens
4 tāla (catustāla)		Bhūtāṅga
3 tāla (tritāla)		Yakṣa and Kinnara
2 tāla (dvitāla)		Kūrma (tortoice)
		Matsya (fish)
1 tāla (ekatāla)		Pannaga (serpent)

The tāla system is relevant with regard to the total height of the image only. The tāla or the face length is not a module of these images regulating the several body proportion. This module (mātrā) is aṅgula or its multiples (1 golaka = 2 aṅgula and 1 parva = 3 aṅgula). The applications of this modular measure for the proportionate measurement is aptly demonstrated in the navatāla system. In this case the total height of 108 aṅgula is distributed among 10 divisions of the body as given in the following table.

Dimensions of the body		Aṅgula measures of each division: Uttama	Madhyama	Adhama
Top of the head to the top of forehead			3	
Face-forehead	4			
nose	4		12	
lips	2			
cheeks			2	
Neck			3	
Neck to the horizontal line through heart			12	
From the level of heart to that of nābhi (navel)			12	
Navel to genitalia			12	
Thigh			24	
Knee			3	
Leg			24	
Foot			3	
			108	

The procedure for sculpturing the image is first to select the stone

of length equal to twice the image height and of width equal to 3/4 the image height and of thickness half this width. The stone is fixed firmly on the ground and the 11 horizontal lines corresponding to the above divisions are marked on the stone slab. Horizontal lines are also drawn corresponding to the measures of padmapīṭha pedestal, base of pedestal, top of the crown, and midpoints of thighs and legs. The vertical lines through the centre, ears, shoulders and the limits of weapons are also drawn. Based on these reference lines the different parts of the body are marked. The dimensions of each part are given in the Āgama text on iconography.

For the female figure in navatāla the vertical proportions as given are adopted as such. But the lateral dimensions are modified to suit a female figure. These parametric dimensions for male and female images are indicated in the table below:

Body parts	**Male Image**	**Female Image**
Width of face	12A	11A
Neck	8A	7A
Bhuja	24A	17A
Breast (nipples)	12A	18A
Belly	16 A	11A
Waist	18A	20A
Thigh	24A	24A
Knee	10A	7A
Calf	7A	6A
Feet	5A	4A
	108A	108A

The three varieties of images - uttama, madhyama and adhama - in each tāla category are obtained by varying the dimensions of the median image in table below the neck. Thus the uttamanavatāla category of image will have the body height below the neck increased 4 A and adhamanavatāla category of image will have the body height

reduced by 4 aṅgula. Craftsmen are free to incorporate minor changes in the features of the image within these prescriptions.

The tālamāna is clearly based on the physiognomonical types particular to different regions of India. Basically the iconometric proportions of adult body appear to belong to the three categories - saptatāla, aṣṭatāla and navatāla - of ethnic groups. Those of the saptatāla category are of stouter proportions as compared to navatāla category of slender stature. The aṣṭatāla group are of meadian or average stature, consequently the aṣṭatāla proportions are used to portray human beings in iconography.

	Aṣṭatāla			**Navatāla**			**Daśatāla**		
	A	M	H	A	M	H	A	M	H
1. From top of head to forehead		3		3	3	3		4	
2. Face		12		12	12	12		13	
3. Neck		3		3	3	3		4	
4. Neck to level of heart		10		$11\frac{1}{2}$	12	$12\frac{1}{2}$		13	
5. Level of heart to nābhi		10		$11\frac{1}{2}$	12	$12\frac{1}{2}$		13	
6. Nābhi to genitalia		10		$11\frac{1}{2}$	12	$12\frac{1}{2}$		13	
7. Thigh		21		23	24	25		26	
8. Knee		3		$2\frac{3}{4}$	3	$3\frac{1}{4}$		4	
9. Leg		21		23	24	25		26	
10. Foot		3		$2\frac{3}{4}$	3	$3\frac{1}{4}$		4	
		96		104	108	112		120	

The aṅgula measures of saptatāla, aṣṭatāla and navatāla categories are 84, 96 and 108 respectively. But in all cases the measures of the face are same, equal to 1 tāla or 12 aṅgula. It is also seen that the height of the body (from the top of head to the genitalia) is equal to the height of the leg (thigh, knee, leg and foot). Hence the portions below the neck are shorter for saptatāla and aṣṭatāla images as compared to that of the navatāla type. The net effect is that the saptatāla image will appear sturdy where navatāla image will look comparatively slender. As the aṣṭatāla system is used to carve human images, the saptatāla will suit the images of demons while the navatāla

system will produce elegant images of gods. Extending this concept further, the ṣaṭṭāla will be appropriate for dwarfs and daśatāla will be fit the supreme dieties of Brahmā, Viṣṇu, Śiva and their spouses. The pañcatāla system has different measures for lateral dimensions and these are used to depict Gaṇeśa in stouter proportions, Vāmana in dwarfish proportion and Kumāra in the body proportion of a child. The versatility of the tālamāna is fully used in this case.

VII. Adornment of Images

The gods, demigods, humans and demons represented in sculpture are in different aspects of their being, in a variety of postures and expressing a range of emotions. Gods may be represented in peaceful (śānta) or terrific (ugra) aspects. While the śāntamūrti will be sculptured with gentle expressions on face and compressed statue, the ugramūrti will be inflated with devine fury with bulging eyes, puffed cheeks and in a posture of attack. The different positions taken by images are expressed by changes in the position of head and limb. The sculptural works other than those of images of worship are generally expression of movement and action. Female figures are shown with their bodies swaying, and turning about a vertical axis in space. The emotions on their faces are brought to light by subtle details in carving the eye brows, eyes, cheeks and lips.

Āgamic texts describe each diety with appropriate attire, ornaments and weapons. The preference of the sculptor is for the bare body and he makes only sparing use of garments and ornaments in images. The attire also reflects the original character. The garments appear to cling to the body only with their edges and ends emphasised as if they were ornaments on the body. Ornaments are profuse on the neck, arms, waists, legs and fingers in a bewildering variety. Another important feature is the head gear, the hair being arranged in complex patterns, bedecked with ornaments the whole forming crown like features rising to about 8 aṅgula from the forehead.

Images of gods are also invariably crowned. The crowns appear in a variety of shapes - like many tiered tower, domical, locus shaped,

umbrella shaped and in the shape of tortoise. Often the crowns of gods surpass the faces in height, the heights being 15, 18, 21 or 24 aṅgula. Gods are also often associated with their vehicles on which they are mounted or animals in their guardianship, and attendant demigods. The main diety is then always brought to prominence by the sculpturing of an aura (prabhā). The system of enframing images in the portals (toraṇaprabhā) is also followed in many cases. Every detail of the images are spelled out in treatises on iconography. Strictly speaking, sculpture and iconography are not part of architecture. But it is impossible to separate them from temple architecture, which is a synthesis of engineering sciences (vāstuśātra), sculpture (śilpa) and theistic rituals of worship (āgamas).

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Tantrasamuccaya

Jayan Erancheri Illam

Tantrsamuccaya (TS) is a well known text in the field of tantra and vāstuvidyā in Kerala. It is considered as an authoritative text on these fields. Author of the work is Cennās Nārāyaṇan Nampūtiripād. He is believed to be the court scholar of King Mānavikrama, the Zamorin of Calicut. It is according to the instruction of Manavikrama, that Cennās wrote *TS*.

TS is the work of 15th c AD. 1427 AD is the year of the birth of the author. It is clear from the chronogram in the text. As its name indicates it is the samuccaya or collection of the tantras of different deities. *TS* deals with the worship of seven deities, Viṣṇu, Śiva, Subrahmaṇya, Durgā, Śāstā and Śaṅkaranārāyaṇa. It also deals with construction of temples. The process from testing of the land upto the construction of multileveled prāsāda is described. It is an elaborate work containing twelve chapters called paṭalas.

Contents of the Text

Acāryavaraṇa (accepting an ācārya or priest for construction of the temple) to śilāparigraha (testing and acceptance of stone) are described in the first chapter. The second chapter contains architecture details connected with temple portion, measures of prāsāda, garbhagṛha, bimbas and construction of single and multileveled

prāsādas. The next chapter describes mantras of different deities and dravyas (offering materials that can be used for pūjā of deities). It also deals with kalaśas used for special pūjās and dravyas (materials that can be used in kalaśas). The fourth chapter gives details about the rituals of maṇḍapasamskāra and gobandhanakriyā.These are parts of pratiṣṭhā rituals. The fifth chapter deals with dehaśuddhi, prāṇāyāma, lipinyāsa and such rituals that are to be done by ācāraya while offering pūjā. They are for mental purification. The rituals mentioned third to fifth are the part of pratiṣṭhā or installation of deity. In the sixth chapter main rituals connected with pratiṣṭhā are described. Daily rituals are discussed in the following chapter. Kalaśas used for abhiṣeka are given in chapter VIII. Rituals that are to be observed in the festivals of temples are given in the next chapter. Prāyaścittas are described in tenth chapter. Prāyaścitta means the ritual to be done in the case of occurrence of any impurity in the temple. Prāyaścittas are to be observed if any fault had occurred in the worship of deity. Reconstruction of a decayed temple is the matter discussed in chapter XI. This deals with the matters like construction of a small shrine room for deity, while the temple is being repaired. Rituals that are to be observed during the construction are also described. Twelfth one is the concluding chapter. It deals with the matters that are left behind in the earlier chapters about the construction of temple.

Aspects of Temple Architecture

TS describes architecture in one chapter only. That is the second one. This chapter gives all the minute details of temple construction. It begins with the testing of the land proper for a temple.This include, testing of the land according to its surroundings, the caste of the owner, the shape of the land, the geographical conditions, and the result that are obtained by worshipping a particular deity in a land. Construction of temple begins after the selection of land. Placing of bricks for the temple construction for the first time is known as iṣṭakā nyāsa - placement of bricks. This is done in the place where the installation of deity will be made after the construction of the temple. A bronze pot known as garbhapātra is placed over the

bricks.This ritual is known as garbhanyāsa. Over this, six portions of the base known as ṣaḍhādhāras are placed .These are (1) ādhāraśilā, (2) dhānyapīṭha, (3) nidhikalaśa, (4) śilāpadma, (5) śilākūrma and (6) yoganāḷa.

The height of the pillar of the prāsāda is decided first. The height of the prāsāḍa pillar determines many measures of the parts of the temple. Height of the adhiṣṭhāna is then decided based on the height of prāsāda pillar.

Selection of stones for temple is an important part of the construction.There are male stones, female stones and neuter ones based on their peculiarities. Male stone is used for construction of bimba, female stone is used for construction of pīṭha and neuter stone is used for napumsakaśilā below the pīṭha. Peculiarities of each type of stone is described in the following verse:

gurvī dhīraravā sphuliṅgabahulā nyagrodhabodhicchadā
prakhyā bimbavidhau viśālabahulagrāhyā śilā pauruṣī /
rambhāpatranibhā nacātibahulā snigdhasvarā śītalā
straiṇī pīṭhavidhau dvilakṣmibhidurā klaibī padābjārpaṇe //

Prāsāda is the main portion of the temple. This includes garbha gṛha or shrine room, its corridor and an outer wall surrounding the corridor. In small temples the shrine room itself is known as prāsāda. Measures of prāsāda are decided based on the decided height of its pillar.

The decided measures for prāsāda and other portions of temples are tested using traditional calculation systems of āya, vyaya, yoni, tithi, vāra etc. If the selected measures are found proper using this calculations, they are accepted. Otherwise the decided measures are to be changed.

Types of Prāsāda

TS mentions ten types of prāsādas based on their shapes and measures. They are jāti, chanda,vikalpa, ābhāsa, vṛtta, dīrghavṛtta, gajapṛṣṭha, caturaśra, aṣṭāśra, and ṣaḍaśra. Jāti to ābhāsa are rectangular

in shape, varying in measures. Others indicate their shape by their name itself. These prāsādas can be constructed as single leveled or multileveled. The main parts of prāsāda are adhiṣṭhāna (base), gomukha (water outlet), vedikā (portion of base floor), prāsādadvāra (entrance to prāsāda), bhittikā (wall), and roof of prāsāda.

All these portions should have decorations. Decorative portions of adhiṣṭhāna are (1) pādukā, (2) jagati, (3) kumuda, (4) kumudapaṭṭikā, (5) gala, (6) galapaṭṭikā, and (7) vajana. The decorative portions of prāsāda are (1) ghanadvāra, (2) toraṇa, (3) śālakūṭa, (4) pañjara, (5) jālaka and (6) kumbhalatā. In the construction of multileveled prāsāda the inner wall or āruḍhabhitti is made to be higher. This is for construction of second level. Beams of the roof of second level are placed over this wall. In the second level also the wall portion is well decorated.

The other parts of temple is outside prāsāda.The main exterior portions of prāsāda are mukhamaṇḍapa, pañcaprākāras, balipīṭha, dhvaja and gopura. There are standardised norms for deciding the measures of these portions, and they are also used for deciding the distance between each portion. Daṇḍa and mukhāyāma are these standardised measures.They are fixed according to the diameter of breadth of the base floor. Uniformity in measures is essential for construction. So these standardized measures are used in the calculation of those of other parts. Among the above mentioned exterior portions pañcaprākāras are the five concentric exterior areas which includes different parts of temple. They are antarmaṇḍala, antahāra, madhyahāra, bāhyahāra and prākāra.

TS discusses in detail the making of idols. Idols made of stone with details of measures of all portions are given. Tāla measure is used in the sculpturing of idol. Daśatāla devī bimba, navatāla deva bimba and pañcatāla Gaṇapatibimba are described in this text. Though we find idols made of dāru and pañcaloha, main material for idol construction is stone itself. Construction of different types of Śivaliṅga is also described.

Rituals

TS gives much importance to rituals of temples. A ritual means the observation of Vedic or tāntric practices for pleasing the deity. The rituals described in *TS* can be classified as (1) rituals observed during the construction of temples, (2) rituals of pratiṣṭhā (installation), (3) nitya (4) utsava (festival) rituals and (5) prāyaścitta (expia) rituals. *TS* gives description of homakuṇḍa, mudrās and padmas made for different rituals.

The study of *TS* provides one with the knowledge that the ancient Sanskrit texts are still of modern relevance in some aspects.The measures and construction styles described in *TS* give us the knowledge of ancient construction style of Kerala.The study of such ancient texts will be useful for people to understand our ancient building style and make use of it as far as possible in present days. Even though the materials of construction, social and cultural values, and needs of human beings are changing day by day, some basic principles are not changing. Hence echo-friendly architecture is of value in some matters. *TS,* considered as a tantric text, gives us the knowledge of the culture of temples of Kerala.This culture is a mixture of Vedic sacrifice and ritualistic worship. This text can be classified among the texts of dakṣiṇamārga tantra. It is Vedic in nature. *TS* mentions the caste system, which was prevalent in its time. Though it was not directly connected with temples, it existed as part of the society.



Textual Tradition on Temple Architecture based on Puṭayūr Bhāṣa

K. N. Neelakantan Elayath

Kriyādīpikā popularly known as *Puṭayūr bhāṣa*[1] composed by Vāsudevan of Puṭayūr Illam in North Malabar is a treatise on temple rituals. It is a tantric work of āgama type and as such deals with all facets of God's dwellings from the choice of the site for the construction of temple to iconography and decorations. Written in maṇipravāḷa style (hybrid of Sanskrit and Malayalam) it is the most popular work in tantric tradition of Kerala and like similar works deals with rituals connected with the construction and consecration of temples and daily worship. The work is intended to be a manual not only for the temple-priests and tantrīs (authority and supervisor of temple rituals) but also for temple architects. Being the oldest work in vernacular, it is of great importance, especially when ancient technical works are studied for their possible modern application.

Author

The author of the work Vasudevan of Puṭayūr Illam hailed from a Namboodiri family at Taḷipparambu in North Malabar. Though there were many houses bearing the name Puṭayūr Illam at Talipparambu the present author belongs to Pūntoṭṭattu Puṭayūr Illam. From the work we know[2] that his father's name was Nārāyaṇa. His preceptor was Pāṇḍuraṅga and he was devoted to Śiva, the deity of the temple at Talipparambu - the diety often mentioned as *Cellūrnātha*. He has also authored another work called *Puṭayūr bhāṣa* dealing with the smārta

rituals of the Baudhāyanas and *Ekasvāsa*, a work on expiatory ceremonies.

Text

The original name of the work is *Kriyādīpika* and is intended to be an easy manual for tantrīs to cross the ocean of tantra.[3] But on account of its composition by Puṭayūr Vāsudevan, in Malayalam-Sanskrit mixed language it was called *Puṭayūr bhāṣa.* It is divided into 12 paṭalas or chapters and consists of 2944 verses in anuṣṭup metre. The work is the earliest one of this type in Kerala and was composed at least one hundred years before *Tantrasamuccaya,* the most popular Sanskrit work on tantra. According to some[4] the word cellūradhipatījyeyam occurring in the 12th *paṭala* contains a chronogram which gives the year of its composition as 1342 A.D. The author of *Tantrasamuccaya* was born in 1427-28 A.D (*kalyabdeṣvatiyatsu nandanayaneṣvambodhisaṅkhyeṣu yaḥ sambhūto).* In the division of chapters and in the treatment of different topics *Puṭayūr bhāṣa* has striking similarities with *Tantrasamuccaya.* Many verses are even seen to be translations of *Puṭayūr bhāṣa*.[5] Therefore it is likely that this work is original and *Tantrasamuccaya* is only a later version of it into Sanskrit by Cennās Narayanan Namboodiri. Though the latter was considered authoritative, it is the *Puṭayūr bhāṣā* and another work K*uzhikāṭṭu pacca* which were followed by the tantrīs and carpenters of Kerala in actual practice. *Puṭayūr bhāṣā* like *Tantrasamuccaya* deals with the worship of seven deities, viz, Viṣṇu, Śiva, Śaṅkaranārāyaṇa, Durgā, Subrahmaṇya, Gaṇapati and Śāstā. It is also possible that both the above works followed some common sources like *Prayogamañjarī* and *Prapañcasāra* which were not accessible to those who did not know Sanskrit.

Philosophy

The philosophy underlying the rituals related to temple worship is that the Paramātmā assumes many forms and becomes an object of worship to devotees. According to the Āgamas, installation of deities and their worship brings prosperity to human beings. Temple - rituals

in most of the tantra works begin with the selection of a guru (guruvaraṇa) and one has to follow the instructions of the preceptor in the installation and consecration of the deity. It is said that the deity with all its glory will be present in the idols if it is properly installed and worshipped with daily pūjās and festivals. Defect in the performance of rituals may affect the presence of the diety in the idols and bring calamity to human beings.

Summary of the Text

The following are the main topics discussed in the 12 chapters of *Puṭayūr bhāṣa*. The first chapter contains the selection of the guru, selection of a suitable site for temple-construction, purification of the site or *vāstubali*, lying of the foundation-stone and the selection of granite. The second chapter deals with the details of the construction of prāsāda from pādukā to stūpikā , different types of prāsādas, types of idols and then measurements and the construction of balipīṭhas and pañcaprākāras. In the third chapter purification of the idol and related rituals are given, while the fourth chapter dwells on purification of the seven deities and the maṇḍapa. The fifth chapter deals with rituals connected with the actual installation of the deities. The sixth is devoted to the fixing of the idol with aṣṭabandha (a type of wax), installation of balipīṭhas and flag-staff and their purification ceremonies. The seventh chapter is mainly concerned with the details of the daily rituals in temples. The eigth chapter takes up the topic of kalaśapūjā, the modes of pots, different types of diagrams ranging from the one to sixteen depending on the number of pots (usually 25 to 1000). Chapter nine briefly narrates different festivals while the tenth chapter is devoted to expiatory ceremonies or prāyaścittas ie; the sight of bad-omens inside the temple indicative of an impending calamity and their prevention by expiations. The ill-omens are said to be death, presence of urine, blood etc, entry of caṇḍālas and theives and presence of honey-bee and mushrooms. Other ill-omens are breaking of the conch and the thread during the selection of the site. The eleventh chapter gives the details of the renovation of temple and the installed idol and the last chapter contains miscellaneuos subjects not mentioned in the earlier

chapters. They include description of several rituals, of untensils of temple-worship like sruva and juhū and their precise measurements. It also contains some details on the determination of directions, and fixing the post for construction of the temple which are not mentioned in the second chapter.

Contents of the Second Chapter

From the point of view of vāstuvidyā, the second paṭala dealing with the construction of temple and iconography deserves special mention. This chapter contains 325 verses and elaborately deals with different types of temples and their constructions with its various dimensions like hight, width and length. Accrodingly, there are 13 types of prāsādas which can be again classified into chanda etc. It is followd by an account of the yoni-concept, their determinations, and the star, and age of the vāstu. The measurements of different parts of the temple from pādukā to stūpikā, construction of the basement and its parts, erection of pillars, both dārumaya and kuḍya etc. are further explained. Construction of prastara, the third main part of the temple, and its various types are then described. This is followed by the prescription regarding the śikhara, the roof structure, measurments and type of rafters paṭṭikā, tulā etc., and finally the fixing of the stūpikā. The roof may be covered either with copper plates or tiles.

Puṭayūr bhāṣa also gives a detailed account of different types of temples like alpaprāsādas and mahāprāsādas and their features. Temples with three to five stories are called jāti. Both three-storied and four-storied temples again are of six types. The features of other types like chanda, vikalpa and ābhāsa are also given in this context. On the basis of shape, temples are classified as square, rectangular and circular, viz. nāgara, drāviḍa and vesara. Construction of mukhamaṇḍapa, arcanāmaṇḍapa, five prākāras and sabhā and installation of flag-staff etc. are other subjects treated in this chapter of *Puṭayūr bhāṣa*.

Verses 193 to 321 in this chapter focus on idols and measurments in respect of the seven deities and include minor details of seven ornaments and other decorations. The second chapter ends with a

simple narration of different citras and its three-fold divisions viz., chitra, citrārtha and citrābhāsa.

Renovation

The renovation of temple and installed idols, briefly narrated in the eleventh chapter, makes *Puṭayūr bhāṣa* a comprehensive manual on temple architecture. It gives prescriptions for the twofold renovation called saṅkoca and niṣkramaṇa and their corresponding rituals. In the context of replacement of the old by a new one, the entire ceremonies related to the installation of the idol has to be meticulously performed.

The importance of *Puṭayūr bhāṣa* as a source book of temple architecture has not been properly highlighted. It sheds light on the little known architectural tradition of Kerala. The work takes details of temple-construction certainly from a pan-Indian tradition. But it combines it with a different architectural model and perhaps also adds practical techniques. Whether it gives any new perspective in the practice of temple architecture in Kerala, yet remains to be investigated by a careful analysis and study of the text.

References

1. Published by Panchangam Press, Kunnamkulam, 1889.
2. *Sumanovāṭikājātapuṭayūr vāsudevanāl / maheśvarapitṛvyena paṭhiccuṇṭāyatokkeyum // ślokarūpeṇa bandhiccu bhaṣāmiśrita samkrtaiḥ / ittham kriyādīpikayil naṭe paṭalamīritaḥ //* (12.232) *nārāyaṇa tanūjena cellūrnāthaprasādataḥ* (1.199).
3. *Tantramāya samudrattinnantayāne supotakam* (1.2) *Pratimāsthāpanam ceyyal eḷutāyavidham bruve* (1.3)
4. See introduction to *Puṭayūr bhāṣa* by Kakkat Narayanan Namboodiri.
5. For example see verses of *Puṭayūr bhāṣa* I.25, 181; II.1, 10 and verses of *Tantasamuccaya* I.10, 105, II.1, 6.



Is Tantrasamuccaya an Original Work?

N. V. P. Unithiri

Tantrasamuccaya (TS) of Cennās Nārāyaṇan Namboodiri[1] is one of the most notable contributions that Kerala has ever made to the branch of tantraśāstra. Even today it is considered to be the authority in the field of tantra related to temples.

Though the *Kriyādīpika* known as *Puṭayūr Bhāṣa (PB)* by Vāsudevan Puṭavar of Pūntoṭṭam[2] is not so famous as the *TS*, it is more or less well known among the tantrīs of Kerala. However, it is not in Sanskrit. It is written in Malayalam. Strictly speaking, it is in Maṇipravāla (a mixinig of Sanskrit and Malayalam).

There are twelve chapters called paṭala-s in both *PB* and *TS*. A comparative study of the topics of each chapter of these two works would reveal that the contents of them are more or less the same. When one goes to the details, it can be seen that a good number of the verses in the two treatises appear to be word-by-word translations in many cases, and adaptations in some others. For example, we may give a detailed comparison of chapter I :

PB	*TS*
4	4
15-25	6-10
26-8	11-3
Mantras 1-8 and verse 29	14-5
30-3	24-7
34-7	28-36
38	37-8
39-40	43
41-2	44-5
43	46-7
Prayer hymns of Durgā 1-2	51-2
Prayer hymns of Subrahmaṇya 1-2	48-9
Śāstṛ 1.44-6	50, 53-4
47-58	55-8
59-61, 63-5	59-60
83-5	74
Prayer hymn 1, 86-92	75-8
Prayer hymn 1, 93-5	79-80
96-9	81-2
100-6	83
110-86	88-130
190-8	135-40

In chapter I, only the topic of mantropadeśaprakāra (10 verses) and the contents of verses 71-7 of *PB* are not seen in *TS*. On the other hand, the idea of a few verses such as 5 and 39 - 41 of *TS* does not appear in *PB*.

Coming to chapter II, the contents of both the works are the same. Almost all the verses seem to be word-by-word translations.

From chapter III onwards we may point out a few examples:

PB	TS
III.1-2	III.I
IV.94-95	IV.115
V.1-2	V.1
VI.194-97	VI.136
VII.1-2	VII.2
VIII.158-61	VIII.128-9
IX.63-4	IX.47
X.64-6	X.15-6
X1.179-82	X1.81
Beginning prose portion	
XII	XII.1

The last chapter of both the works deals with the rituals, definitions of things for worship and other matters which were not treated in the previous chapters. There we may compare, for example:

PB XII.225-30 *TS* XII.213-4

This comparative study of the verses, taken from the beginning, middle and the end of the chapters in both these treatises, reveals without any doubt that the similarity of ideas is striking in a majority of cases; it appears to be a word-by-word rendering.

PB. 1.1-3, 1.199, II.325, III.160, IV.96, V.137, VI.198, VII.178, VIII.420, IX.179, X.585, XI.232 and XII.231-8 make it clear that the real name of the work *Kriyāadīpika* and that it is known as *Puṭavar Bhāṣa* or *Poṭavar Bhāṣa* (published in the name *Puṭayūr Bhāṣa)* and that the author of the work is Vāsudevan of Pūntoṭṭam (*sumanovāṭīkā* is the Sanskritized form which is seen in *PB* XII.233) who is a devotee of Cellūrnātha (God Śiva of Talipparamba).[3] According to Kāṇippayyūr Śaṅkaran Namboodiri,who is the publisher of *PB*[4] and Kakkad Narayanan Namboodiri, who was a well-known tantrī[5] the phrase *cellūradhipatījyeyam* (*PB* XI.237) denotes the Kali chronogram which corresponds to A.D.1343. We know that the Kali chronogram in *TS* XII.215 i.e. *'kalyabdeṣvatiyatsu nandanayaneṣv*

ambhodhisaṅkhyeṣu' corresponds to A.D 1429. Thus it can be seen that *TS* was written 86 years after the composition of *PB.*

According to tradition, there were sixty-four Brahmin villages in ancient Kerala (32 in the Tulu area and 32 in Kerala proper), and Peruñcellūr (modern Talipparamba) was very much prominent among them. In Kathakali, Kūḍiyāṭṭam and other temple art forms even today artists feel extremely proud of getting recognition by way of presentations from Perumtṛkkovilappan, the deity of Talipparamba, in the village temple of Peruñcellūr. Similarly, tradition maintains that in all matters Peruñcellūr was the unquestionable authority. Tantra was not an exception to this.[6] Thus it is quite appropriate to hold that *PB* originating from Peruñcellūr, was considered an authority in the field of tantra and that in order to popularize the ideas of *PB* all over India, Cennās Nārāyaṇan Namboodiri composed this tantra work in Sanskrit. Regarding the situation prevalent four or five centuries back, this was really possible. During that period, Sanskrit was the scholarly language at an all-India level. Only a work written in that language could enjoy nation-wide recognition and fame.

According to some scholars, *Bhāgavata* was composed in Sanskrit in the 9th century A.D. by a South Indian poet with a view to making popular all over India the emotional devotion which was propagated by the Āḷvārs in the whole Tamil country through their Tamil songs. It is well known that now-a-days, in order to gain popularity all over the world, we publish in English ideas already available in regional languages. The status English occupies today was the one enjoyed by Sanskrit in the early and medieval periods in India. In this circumstance, it can be presumed that the contents of *PB* were made availabe in Sanskrit in the form of *TS.*

Now there may arise a question: If this is the case, then why did Cennās Namboodiri not give any acknowlegdement of this in his *TS*? The answer is clear : He had already admitted that he composed the *TS* collecting matters from a number of tantra treatises.[7] He did not mention the name of any text. So he did not refer to *PB* also which he mainly

depended upon. Another reason for not mentioning the name of *PB* may be that it was a Malayalam (Maṇipravāḷa) work. A few texts like *Manuṣyālayacandrikā* give a comprehensive list of works that they are based on. Even there we do not find the name of any non-Sanskrit works.

On the other hand, if *PB* was written , imitating and depending on *TS,* that fact would have been acknowledged in the work itself, just as in the case of the *Kuzhikkāṭṭu pacca,* which is an adaptation of *TS* and *PB* would have been known to us as an adaptation or free translation of *TS.* It is rather strange that in a regional language work, acknowledgement of the original Sanskrit is not made, especially of a reputed work like *TS.*

Thus we may come to the reasonable conclusion that the Kali chronogram in *PB* is to be taken as seriously as the one in *TS* and that *TS* was composed, imitating and depending upon *PB* as a free rendering of it[8].

References

1. Edited by T. Ganpati Sastri, Nag Publishers, Delhi, 1989.
2. Edited by Uliyathillath Raman Vazhunnavar, Panchangam Pustakasala, Kunnamkulam, Kerala, 1989.
3. Vide also, Ullur S. Parameswara Iyer, *Keralasāhityacaritram,* University of Kerala, Thiruvananthapuram, 1990, vol,III, pp .222-3.
4. *PB,* p.iii.
5. *ibid,* p.vi
6. Kanippayyur Krishnan Namboodiri, an authority of tantra and Vāstuvidyā in Kerala today, told me this in a private conversation.
7. *tantram idam vyadhād bahuvidhād uddhṛtya tantrārṇavāt* (*TS,* XII.215)
8. When this paper was published in *Adyar Library Bulletin,* 2000, Dr. K. Kunjunni Raja, the editor of the Journal, had given an Editorial Note, which is reproduced below:

"Professor Unithiri's arguments are interesting and logical; but we

feel a psychological resistance to accept his thesis. *TS* is studied as a text book on Kerala temples, and also those in Tulunad. K.P.C. who translated it into Malayalam had not consulted it.

The Kali date of *PB* is not certain, though possible. The similarity between the two works is striking and the dependence of one on the other is certain. A detailed comparative study may help us to decide the truth. We are thankful to Prof. Unithiri for raising this problem to the attention of those working in the field."



Manuṣyālayacandrikā

Jyotsna G

Architecture is one of the fields of technical literature where Sanskrit had its landmark. The foundation of architecture or vāstuśāstra is found in the *Sthāpatyaveda* which is a part of *Atharvaveda*. This contained treatments on mathematics, graphic arts, structural engineering, sculptural arts etc. The treatments of vāstuvidyā is also found in the samhitās and purāṇas. For eg:- *Matsyapurāṇa* describes architecture and sculpture. *Nāṭyaśāstra* and *Padmasamhitā* contain elaborate treatment on design and construction of theatres and planning and construction of temples respectively.

Vāstuvidyā is also included in Varāhamihira's *Bṛhatsamhitā* of about 6th centuary A.D. Later some more books came in this field like i) *Īśānaśivagurudevapaddhati,* ii) *Kāmikāgama,* iii) *Samarāṅkaṇa sūtradhāra,* iv) *Mayamata,* v) *Mānasāra* etc. However the variations caused by the geoemtric and climatic features are accommodated in regional texts like *Tantrasamuccaya* of Cennas Narayanan Namboodiri, *Śilparatna* of Śrīkumāra, *Manuṣyālayacandrikā* of Tirumangalath Nīlakaṇṭhan Mūsat. These books cover the vāstuvidyā practiced in Kerala.

Of these books *Manuṣyālayacandrikā (MC)* is the most popular among the artisans and sthapatis in Kerala.

As the name denotes *MC* deals with domestic architecture. The

author himself gives his identity in the beginning of the text:

श्रीमङ्गलास्पदसदाश्रयनीलकण्ठ-
प्रेमप्रकर्षनिलयः सकलाभिवन्द्यः ।
श्रीमद्गिरीन्द्रतनयातनयोऽङ्घ्रिभाजां
कामप्रदो जयति मत्तमतङ्गजास्यः ।। (I.3)

Enshrined in Śrīmaṅgala (Tirumaṅgala) kṣetra, the elephant- faced Gaṇeśa, who is the refuge of good people, who is beloved of Śiva, is worshipped by all, who is the son of revered Pārvatī and who grants the wishes of the devotees, remains with glory.[1]

In the beginning itself he pays tributes to the deities in temples near Tirūr. In *MC* and *Kāvyollāsa,* which is the author's another work, he pays tributes to the deities of several temples which are all in Prakāśaviṣaya (Veṭṭattunāṭu), a place near Tirūr. From all these evidences we can understand that the author lived at Tirumaṅgalam near Tirūr.

In the first chapter of the book itself Nīlakaṇṭha mentions that *Tantrasamuccaya* is one of his source books. He quotes his references as follows:

मयमतयुगलं प्रयोगमञ्ज-
र्यपि च निबन्धनभास्करीययुग्मम् ।
मनुमतगुरुदेवपद्धतिश्री-
हरियजनादिमहागमा जयन्ति ।।
मार्कण्डेययुगं पराशरमुरारिप्रोक्तरत्नावली-
सारान् काश्यपविश्वकर्ममतयुग्माद्यं कुमारागमम् ।
सव्याख्यां हरिसंहितां विवरणाद्यं वास्तुविद्यादिकान्
दृष्ट्वा तन्त्रसमुच्चयोक्तमनुसृत्यैवात्र संक्षिप्यते ।।

This shows that *MC* was written after *Tantrasamuccaya*. In *Tantrasamuccaya* the birth of the author is given in Kali year as 4529 corresponding to 1429 A.D. From this we can say that Nīlakaṇṭha lived after 15th century A.D.

Ullur. S. Parameswara Iyer says that the author of *MC* was a disciple of Kelallūr Comātiri. The Kali year of Comātiri given in *Tantrasaṅgraha* corresponds to 1501 A.D. From this we can assume that *MC* was composed in 16th century A.D.

The construction of residential buildings forms the subject matter of *MC*. The author himself says that he had referred to āgamas, samhitās and treatises available at that time. He accepts the procedure of *Tantrasamuccaya*. Nīlakaṇṭha studied all the available books of his time for writing *MC*. He critically studied the practices in different parts of the country and adopted only those which appeared him to be acceptable. The basic techniques, theories and philosophy of vāstuvidyā related to residential buildings have thus been unified in this text.

The text is divided into seven chapters.

In the first chapter Nīlakaṇṭha makes clear his references. It deals with the guilds of craftsmen and duties of each guild. It gives rules for the selection of land. It is said:

गोमर्त्यैः फलपुष्पदुग्धतरुभिश्चाढ्या समा प्राक्प्लवा
स्निग्धा धीररवा प्रदक्षिणजलोपेताशुबीजोद्गमा ।
सम्प्रोक्ता बहुपांसुरक्षयजला तुल्या च शीतोष्णयोः
श्रेष्ठा भूरधमा समुक्तविपरीता मिश्रिता मध्यमा ।। (I. 17)[2]

The land, rich with the presence of cattle, human beings, flowering and fruit-bearing trees and trees extruding milky sap, level, sloping towards east, smooth, producing good sound (while walking or tamping), with water flowing in clockwise direction, causing speedy germination of seeds, well compacted, having perennial source of water and with moderate climate is said to be very good. If the characteristics are opposite (to those mentioned) the land is said to be bad and if they are mixed, it is said to be in between (good and bad).

Site to be avoided, desirable and undesirable, slopes of the land, position of trees in the compound, restrictions for construction of houses

near temples etc. are also dealt with here.

It is given as follows: -

आसीत् दैत्यः प्रदृप्तो निजभुजबलवीर्यादिनाक्रान्तकाष्ठा-
निष्ठो द्वेष्टा सुराणां स तु युधि पतितो विद्धगात्रो धरित्र्याम्।
व्याप्तः सर्वत्र पश्चाद् बहुतरपरिवृत्त्यैव पृथ्वीं विमथ्नन्
मर्त्या दुःस्था मुनीन्द्रास्त्वपि च मखभुजस्तावदेवं बभूवुः।। (II.27)

(There was a haughty demon who subdued all the world by his strength, valour etc. and because the enemy of gods, he was exhausted in battle and was made to fall on the ground. Then filling everywhere and circling several times, he agitated the earth. Then the humans became sad. So also the sages and gods became sad.) Again it is said:

सर्वव्याप्तेऽप्यमुष्मिन्नतनु तनुघटाभ्यन्तरे व्योम यद्वत्
तद्वन्नित्यं विशेषान्नगरपुरमहीक्षेत्रखण्डाङ्गणादौ।
उत्ताने नैर्ऋताशाविनिहितचरणे यावदीशान्तशीर्षे
जाते तावन्निषेदुः स्थिरमिह विबुधास्तस्य देहे क्षणेन।। (II.28)

(He lay flat face upwards with his legs in Nirṛti - South West - corner and head in Īśāna - North East - corner, always filling everywhere especially cities, towns, land, quadrants of plots, yard etc. like the ākāśa in small as well as in large pots. Then suddenly the gods permanently occupied on his body.)

The concept of vāstupuruṣa is a basic concept of vastuśāstra. Every vāstu, whether it is large cities or small rooms is pictured as a field in which the vāstupuruṣa is lying flat with face upwards. This chapter also describes the pādadevatas, etc.

Third chapter describes the measurement used in vāstuvidyā. It is recommended on the use of scale as follows :

आदौ चतुर्विंशतिसंमितैर्यो मात्राङ्गुलैरुक्तकरः स एव।
सर्वत्र पूज्यो मतभेदतोऽन्ये सर्वेऽपि च क्वापि यथार्हमिष्टाः।। (III.12)

[That hasta, which was established earlier as being made of 24

mātrāgulas, is respected everywhere. All the others are differing opinions (beliefs) and are liked in some places on the basis of their suitability]. This stresses the universal acceptability of kiṣku (of 24 uttamāṅgula) which is the most popular cubit. Rules for planning settlements, yoni concept, factors of āya, vyaya etc. are also described in this chapter.

In Chapter IV characteristics of different classes of buildings, the procedure of jointing wall plates etc. are detailed. The characteristics of viśuddhabhinnaśālā, śliṣṭabhinnaśālā, samśliṣṭabhinnaśālā etc. are given in detail.

The fifth chapter discusses the parts of house. The author says about the site for drainage thus:

कुर्याद् गृहाय कृतवास्तुपदं समस्तं
मातङ्गभास्करनृपाङ्गुलमात्रतुङ्गम् ।
बाह्यान्तराङ्गणगतान् गमनाय मध्य-
निम्नत्वदोषविरहाय च मृच्छिलाद्यैः ।। (V.1)

(For the flow of water from the outer and inner yards and to avoid the defect of depression in the middle, the entire area earmarked for the building should be raised by 8, 12 or 16 aṅgulas with soil, stone etc).

The sixth chapter discusses the elements of roof. The uttara used in small and large houses are shown as below:

अल्पे धामनि बाह्यमेव महति त्वारूढमप्युत्तरं
विष्कम्भे तनुयात् स्वगेहविहितैर्योन्यादिभिः संयुतम् ।
वस्वृष्यर्कयुगाङ्गुलादिगतिरन्तः स्यादलिन्दं तु तत्
तावत् स्वोच्छ्रयमस्य कर्णसदृशी विष्कम्भपादायतिः ।। (VI. 1)

(In small houses, only the outer bāhyottara is sufficient; in large houses the raised uttara also occurs. That is to be done over the tie beam with inward. Shift of 8, 16, 24 etc. aṅgula and yonis etc. prescribed for that house. Its rise is same as the shift. The length of the supporting strut of the beam is equal to its diagonal.)

In chapter VII the description of ancillary structures is given. The portion and details of doors, location of main entry and exit doors of buildings, location of farm house, well, etc. are discussed in this chapter.

MC is much popular in Kerala. More than a dozen commentaries written in Malayalam show the popularity of the book. This book can be followed by those who have some knowledge on vāstuvidyā. Several translations in Malayalam helped the craftsmen to understand the work. It gives a systematic procedure for planning, designing and constructing houses together with ancillary structures. *MC* may be the first attempt to elevate the construction of house buildings from the level of a craft to that of a science.

References

1. All translations of the verses are taken from *Manuṣyālayacandrikā bhāṣya.* (I. 7, 8)
2. This verse is identical with *TS*, I.30.



Śilparatna

N. V. P. Unithiri

Śilparatna (*SR*)[1] is an important Kerala classic on traditional Indian architecture written in Sanskrit. Three other works are also equally important, namely, *Tantrasamuccaya* (*TS*)[2] by Cennās Nārāyaṇan Namboodiri (15th century A.D.), *Vāstuvidyā*[3] of unknown authorship, and *Manuṣyālayacandrikā* (*MC*)[4] by Tirumaṅṅalattu Nīlakaṇṭhan Mūsat (16th century A.D). It is to be noted that *SR* is the biggest one among these.

The author of *SR* is Śrīkumāran Namboodiri, son of Rāman Namboodiri, who belonged to Bhārgavagotra. Śrīkumāra was in the court of King Devanārāyaṇa (Pūrāṭam Tirunāl Tampūran of Campakaśśeri of South Kerala), who was the patron of Melputtūr Nārāyaṇa Bhaṭṭatiri, the famous author of *Nārāyaṇīya, Prakriyāsarvasva, Dhātukāvya* and a lot of Campūprabandhas. It was according to the suggestion of King Devanārāyaṇa that Śrīkumāra wrote *SR*[5]. Thus we can assign Śrīkumāra to the 17th century A.D. It is assumed that the birthplace of the author is Ciramelkāṭu (setūrdhvakānana is the Sanskritized form) near Kunnamkulam in Triśśūr District[6].

SR is printed in two parts. Part 1 contains 46 chapters. In total there are about 2480 verses. The first chapter begins with a few salutary verses. After saluting Brahmā, Viśvakarmā and Maya, who are appropriate to be propitiated in a work like this, the author offers

obeisance to his family deity, Subrahmaṇya, and to the sages like Mataṅga, Bhṛgu, Kāśyapa and Agastya, and to his father. Then he says that he has written this work at the instance of the king of Campakaśśeri. Following these salutations, the author gives the contents of the book.

In the first chapter, the author takes up the definition of ācārya (learned preceptor). Here we have the definitions of different kinds of śilpīs (building craftsmen), namely, sthapati (master builder), sūtragrāhī (supervisor), takṣaka (shaper of building components) and vardhaki (one who assembles the different building components). The thirtieth verse in this chapter is identical with *TS*, I.5. The verses 35-37 are similar to *MC*, I.11-13[7]. Various types of measurements like paramāṇu (the smallest linear mesaurement), trasareṇu (the minute aerosol seen in a dark room when sun's rays creep into it through crevices), vālāgra, līkṣā (8 trasareṇus), jūka (8 līkṣās), yava (barley grain- a linear measurement equal to 3.75mm.), mānāṅgula (the standardized measure of aṅgula, by equating it to the grain size 6, 7or 8 in number denoting the minimum, median or maximum width), mātrāṅgula (mesaurement of aṅgula related to the body mesaure), muṣṭi (fist- three aṅgulas), vitasti (12 aṅgulas), hasta or kiṣku (standard hasta equal to 72 cm), daṇḍa (96 aṅgulas) and yojana (8000 daṇḍa) are described in the next chapter.

Chapter 3 contains the definition of different sorts of site like the best, mediocre and the lowest; pūrṇā (land located on top of plateaus or mountain valleys), supadmā (land in the plains with favourable conditions of water and flora), bhadrā (land located at the side of sea, river or lake with good resource of water and facilities for cultivation) and dhūmrā (arid land with hard ground, wild vegetation and wild animals); and vāruṇī (western), aindrī (eastern), āgneyī (south eastern) and vāyavī (north western) . Details of trees to be planted and those to be avoided in the surroundings of buildings are also given here. The characteristics of vīthī (path) to be constructed in the premises of the buildings are also noted. The fourth chapter describes how to select the plot and fix the śaṅku (gnomon) for marking centre of the dwelling place and to plough the land. Good and bad omens are noted in this

connection. Then the author takes the definition and other details of a plough. Sowing seeds, watering them and cutting them after their growth, and giving them to the cattle, and repetition of the same for a few days, are described in the end.

In the fifth chapter, we have the definition of maṅgala (Brahmin settlement), pura (town of religious or residential importance), grāma (village) and maṭha (abode of seers). Then come the definition and description of village, kheṭaka (tribal settlement), kharvaṭa (border settlement), durga (fort), nagara (large urban settlement), rājadhānī (capital city), pattana (commercial town), droṇīmukha (harbour town), śibira (military camp), skandhāvāra (cantonment), sthānīya (check post), viḍambaka (village occupied mainly by cultivators), nigama (village occupied prominently by craftsmen) and śākhānagara (satellite town). Seven kinds of fort are described in detail. Size of village etc is given thereafter. Then the author explains eight types of settlement planning of village etc, namely, daṇḍaka, svastika, prastara, prakīrṇaka, nandyāvarta, parāga, padmaka and śrīpratiṣṭhita. These are differentiated mainly on the basis of the number of streets they have. In village etc, gardens, ponds, residence of people belonging to various castes and workers like carpenters are to be constructed. The proper places for them are prescribed here. Similarly, appropriate places for cooking hall, bedroom, recreation club and others are also pointed out.

Next chapter is devoted for the description of different kinds of square cell and their analysis by dividing the area into cells by means of grids. Seventh chapter is on vāstupūjā (worship of the dwelling place). In the following chapter we have the procedure of making entrance gates in village etc. Details of good and bad effects in constructing them in various directions are aslo noted.

Ninth chapter prescribes the rules and regulations for the construction of temples in village etc. How to dig up the earth for the construction of the structures of sanctum sanctorum is the subject matter of the next chapter. In chapter 11, fixation of directions is

described. Garbhasthāpana (establishment of sanctum sanctorum) is dealt with in the next chapter.

Places where constructions are prohibited by scriptures are noted in the thirteenth chapter.

In the next chapter the author describes the materials for constructing prāsāda (large building like temples and palaces). Definitions of various kinds of stones, procedure for making bricks, mortar, woods prescribed and prohibited, mud and metals- these are the subject of this chapter. Definitions of āya (income), vyaya (expenditure) and yoni (architectural formula for orientation) are the subject matter of chapter 15. These are described in various ways.

In the following chapter we have the definition of prāsāda. Vimāna is another name of prāsāda. Rules of the heights of various forms of prāsādas like śāntika (propitiatory), pauṣṭika (welfare promoting), mahāprāsāda (large temple) and alpaprāsāda (small temple) are noted here. Different types of prāsādas like nāgara (square), vesara (circular) and drāviḍa (octagonal), various kinds of mahāprāsāda (large temple) and padmaprāsāda (lotus temple) are also dealt with in this chapter. Division of the basement of square cell is dealt with in chapter 17. General procedure of the construction of the base, the height of the platform below the basement, description of lotus temple- these are also described in this chapter. The next chapter deals with the definition of upapīṭha (pedestal). Chapter 19 describes the basement. Descriptions of specific patterns of moulding of basement mañcaka, padabandha and pratibandha, construction of kumuda, leveling the ground and necessary instruments for it are the topics dealt with here. Definition of avanata (A-shaped frame used for checking levels of ground), commencement of the construction of a house, patramāna (horizontal distance from outside of wall plate to the outside of the basement) etc, and decoration are some of the other subjects treated in this connection. Description of muṣṭibandha and the rules of the construction of the base for kūṭakoṣṭha etc are also included in this chapter. In the twentieth chapter, nāḷa (stem) is defined.

The following chapter deals with the topic of wall, floor and pillars in detail. Matters pertaining to entrance gates are described in chapter 22. How to build sopāna (a flight of steps) is also dealt with in the end. The next chapter is on ornamental decorations.

Construction of ventilators is the topic of the twenty-fourth chapter. Kūṭakoṣṭha etc are dealt with in the following chapter. Chapter 26 is on wooden roof frames. Definition of vṛttasphuṭitaka is dealt with in the next chapter. In the following chapter, the construction of kumbhalatā is treated. Chapter 29 defines uttara (wall plate) and describes how to construct it. The following chapter describes the various methods of construction of prastara (entablature). The definition and construction of gala (neck or recess in a basement) are the subjects of the thirty-first chapter. The next chapter deals with the definition and construction of śikhara (roof). The definition of lupā (rafter) is the subject of the following chapter. Chapter 34 discusses how to place the bricks on the top of the construction. The definition and construction of nāsikā (nose) are dealt with in the next chapter. Matters connected with kṣudranāsikā (small nose) are also treated here. Mūrtinyāsa is described in the end. In the following chapter, definition and construction of stūpikā (finial) are dealt with. The rules of propitiatory temples and the like are discussed in chapter 37. Multiple storied temples having two to twelve storeys are also described in this chapter.

Chapter 38 gives the definition of circular and hexangular shrines (vṛttaṣaḍaśra-prāsādas). The next chapter is on maṇḍapa (pavilion). Details of the construction of mukhamaṇḍapa (facial pavilion), arcanāmaṇḍapa (pavilion on which deities are kept for worship), adhivāsamaṇḍapa and nāṭyamaṇḍapa (pavilion for performing arts) are dealt with here. In chapter 40, definition and construction of five types of prākāra (boundary wall) and matters connected with dīpamālā (rows of oil lamps fixed on the exterior of them) are discussed. The 41st chapter is on the construction of gopura (gate tower). The construction of parivāra (paraphernalia) is the subject matter of the next chapter. In chapter 43, we have definition and construction of balipīṭha (altar

stone on which offerings are made). Chapter 44 defines the dhvaja (flagstaff) and describes how to construct it. In chapter 45, definition of sandhi (joining the door panels) is dealt with. The next chapter, i.e. the last chapter of the first Part, gives a detailed account of the divisions of painting, the materials, the subjects, preparation of ground and the like. Here we have a clear picture of murals.

SR (Part II) has 35 chapters. It contains about 2150 verses.

After the salutary verse, the author says about the journey in an auspicious time for bringing out idols. In this connection, a list of good and bad omens is presented. If members of the party face bad omens, the journey should be postponed for a month and then, only on seeing good omens, they should start. Idols are seven-fold: that made of stone, jewel, metal, wood, clay, mixture of some of these and that in the form of a picture. There are four kinds of stone according to caste. White, red, yellow and dark stones are related respectively to Brāhmaṇa, Kṣatriya, Vaiśya and Śūdra. Idols for different castes should be made of the respective stones. According to some scholars, all kinds of stones can be used for all kinds of idols. Masculine stones are used for making idols, feminine stones for pīṭhas (elevated seats), and neutral ones for basement . Contrary to this will cause bad effects. Blemishes of stones are pointed out then. Images made of jewel are of eight kinds - that of crystal, ruby, diamond, sapphire, gold, lapis lazuli, coral and topaz. Gains to be achieved by worshipping different types of idols are then listed. It is also maintained that ruby is assigned to sun, pearl to moon, coral to mars, emerald to mercury, topaz to jupiter, diamond to venus, sapphire to saturn, cinnamon to rāhu, and cat's eye to ketu. Nine blemishes of jewel are also enumerated in this context, namely, rekhā (line), bindu (dot), kalaṅka (spot), kākapada (the sign of ^), kṣata (scratching), dhūli (dust), tuṣāra (frostbite), trāsa (alarm) and randhra (hole). Metal images are divided into eight kinds - made of gold, silver, copper, brass, bell metal, iron, lead and tin. Different effects by worshipping each of them are also described. Next comes the description of wooden images. Elaborate description is given of making

idols from clay. There are two types of them: half-cooked and fully cooked. We get a phallic image made of the mixture of many elements, when a wooden dart decorated by metal fillet is coated by clay and then heated. Images painted on walls are also mentioned. Wooden and clay idols fulfill all of your wishes at all time. Jewels can be fitted on clay idols. Images made of sand, cow dung, rice-powder, rice, molasses, fruits and clarified butter are to be given up daily, when their worship is over. Elevated seats are not necessary for these idols. They may be made as and when we want. Descriptions are given here how to make elevated seats for idol. Elevated seats can be made for each type of idols with the same materials by which they are made. Or we can have wooden seats for stone idols, golden or silver seats for the idols made of jewel.

Definition of a phallic image is the subject matter of the second chapter. Eight kinds of images are enumerated. They are divided in many ways. Niṣkala (one without any limbs), sakala (one with limbs) and miśra (mixture of both) - this is one division. Acala (immovable), cala (movable), and calācala (movable and immovable) - this is another one. Image with limbs is of five types - citra, ardhāṅgadarśana, ardhacitra, citrābhāsa and lekhya. The same image is divided into the best, median and the lowest. The image, which is installed with treasure, pot, etc, is called immovable. The one that is worshipped placing on an elevated seat is movable. The image, which is painted on cloths by minerals and paints, is called immovable. In another way, a phallic image is divided into nine types based on placement and measure - by sanctum sanctorum, door, pillar, base, kiṣku and by the measure of the height of the owner. Measurement of Śivaliṅga; phallic images allotted to anuloma and viloma castes; measurements of them assigned to human beings, demons and gods; those belonging to the lowest, median and the highest categories and their measurements; elaborate construction process of metal image; measurements of idols to be installed in square, circular and octagonal temples; divisions of images into sarvasama, samāṁśa, vṛddhyuttara and īśādhika types and their measurements; characteristics of four phallic images, namely,

sarvatobhadra, vardhamāna, īśādhika and svastika; division of phallic image into square etc; ratio of measaurements between phallic image into square etc; ratio of measurements between fallic image and the elevated seat; special features of the Śivaliṅga, namely, chatra, trāpuṣa, kukkuṭāṇḍa, ardhacandra and budbuda, and their mesurements; division of phallic image into sthūlamūla, sthūla, kṛśamadhya, sthūlaśiraska and their description; division of the same into ārṣa and svāyambhuva and their description; details of bāṇaliṅga - all these can be seen in this chapter.

Content of the third chapter is lakṣaṇoddhāra. The construction of mukhaliṅga and structure of architectural formula of orientatiom, week, etc, are also decribed here. The fourth chapter deals with the height of the idol having limbs. The fundamentals of the rule of the modular unit of dimension in terms of face length are also described in this connection. In chapters 5-15, the descriptions of uttamadaśatāla, madhyamadaśatāla, adhamadaśatāla, uttamanavatāla, madhyamanavatāla, adhamanavatāla, aṣṭatāla, saptatāla, ṣaṭtāla, construction of Vighneśvara by uttamapañcatāla and madhyamapañcatāla, and catustāla are given. The contents of the sixteenth chapter are the construction of crown, ear-ring, necklace, brace-let, upper-arm-let, mudrakas, different forms of hand poses like varada, sacred thread, thread on the chest, cannavīra, garland, rosary, skandhamālā, thread on the waist, jālaka, serpent being brace-let, garment, bow, arrow, axe, deer, disc, conch, ḍamaru (a small drum), earthen or wooden water-pot, lotus-seat and nāḷa below it. Chapter 17 describes the making of darts of various gods and goddesses. Binding with string is the content of the eighteenth chapter. Here it is described how to construct the binding with string after covering the dart with veins - the dart, which was already established with aṣṭabandha.

Anointment over the image by specially prepared clay is described in the next chapter. Details of the preparation of the particular clay can be seen here. Chapter 20 deals with the description of the goddesses and Kumāra (Subrahmaṇya), who are to be installed

along with gods. Details of their measaurements are also given. In chapter 21, we have the measurements regarding the construction of 'gods' vehicles like ox, horse and elephant.

The next four chapters present the verses to be meditated in relation to various gods and goddesses. The first among them, ie, chapter 22, consists of verses regarding Śiva. Sukhāsana (easy sitting pose), Somāskandeśvara (the form in which Pārvatī sits on the left of Sukhāsanamūrti in the same seat and Skanda between them sitting or standing or dancing), Candraśekhara (having moon on his forehead) in five forms, Vṛṣārūdha (ascended on an ox), nine Nṛttamūrtis (dancing forms), Gaṅgādhara (bearing the Ganges on his head), Tripurāntaka (destroyer of three cities) in eight forms, Kalyāṇamūrti (auspicious form), Ardhanārīśvara (one having half-male and half-female bodies), Gajaghnamūrti (one who kills an elephent), Pāśupata (one having the form of an ox), Kaṅkālamūrti (a skeleton form), Harihara (one having the forms of Viṣṇu and Śiva), Bhikṣāṭanamūrti (one having the form of begging alms), Caṇḍeśānugraha (one having the form of blessings of the husband of Caṇḍā, a goddess), Dharmavyākhyāna-dakṣiṇāmūrti (Dakṣiṇāmūrti in the form of interpreting dharma or righteousness), Vīṇādhara-dakṣiṇāmūrti (Dakṣiṇāmūrti in the form of playing Lute), Jñāna-dakṣiṇāmūrti (Dakṣiṇāmūrti in the form of knowledge), Yoga-dakṣiṇāmūrti (Dakṣiṇāmūrti in the form of practicing Yoga), Kālāri (destroyer of Time), Liṅgodbhava (originated from liṅga), Śivapañcākṣarī (the form of five syllables denoting Śiva), Rudra, Prasāda, Mṛtyuñjaya, Śaiva Aṣṭākṣara (the form of eight syllables regarding Śiva), Aghora, another type of Mṛtyuñjaya, Cintāmaṇi, Anuṣṭup, Samvāda, Śaktipañcākṣarī, Kālāri[2], Kinnara Śiva, Rakṣoghna, Mūrtis like Sadyojāta - verses in regard to these different kinds of Śaivamūrtis are given in this chapter. Śivaśrīpañcākṣarī verse of this chapter is taken from ***TS*** (VII. 66). Chapter 23 contains verses to be meditated in relation to Viṣṇu. Aṣṭākṣarī, Gāyatrī, Śrīkarāṣṭākṣara, Sudarśana, Nigrahacakra, Nṛsimha, Vidaraṇa Nṛsimha, Ṣaḍakṣarī, Varāha, Caturakṣarī, Dhanvantarī, Hayagrīva, Kārtavīrya, Śrīpañcā mṛta, Santānagopāla, Āvahantī, Puruṣasūkta, Lakṣmīnārāyaṇa, Dvāvimśatyakṣarī,

Vimśatyakṣarī, Aṣṭādaśākṣarī, Śrīrāmaṣaḍakṣara, Rāmadhyānabheda, Gopālakabheda, Śrīkarāṣṭākṣarabheda, Dhanvantarībheda, Aṣṭādaśākṣarībheda, Keśava and others, Varāhabheda, Viśvarūpa, Weapons - verses to be meditated in connection with these deities are given in this chapter. The place of weapons in worship and the like is also described in the end. Chapter 24 contains verses to be meditated in ragard to Śakti. Mūladurgā, Lipi, Bhuvaneśvarī, Hṛllekhā, Vāgīśvarī, Śrī, Tvaritā, Dhūmāvatī, Kālī, Bhelakhī, Mātaṅgī, Śaktipraṇava, Vanadurgā, Trailokyamohinī, Samvit, Indrāṇī, Svayamvarā, Prāṇaśakti, Aśvārūḍhā, Vajraprastāriṇī, Nityaklinnā, Śrīsūkta, Tripuṭā, Tripurā, Bhūmi, Śūlinī, Gāyatrī, Gāyatrī Triṣṭup, Saurī Caturakṣarī, Annapūrṇā, Saptamātṛs - verses to be meditated regarding these goddesses are presented here. In the end of this chapter, permutation and combination of Śrīcakra are also given. Chapter 25 contains verses to be meditated relating to other deities like Indra. Indra, Aindrī Gāyatrī, Aindrī Triṣṭup, Agni, Samvādāgni, Samardhi, Rakṣohāgni, Yama, Nirṛti, Vāyu, Soma, Brahmā, Śeṣa, Mahāgaṇapati, Bījagaṇapati, Heramba, Bālagaṇapati, Subrahmaṇya, Nāgayakṣī, Śāstā, Prabhā, Satyaka among Miśramūrtis; Anuṣṭuptraya, Śaktigaṇapati, Lakṣmīnārāyaṇa, Ardhanārīśvara, Śaṅkaranārāyaṇa, Sūrya, Saura Aṣṭākṣara, Kāma, Vīrabhadra, Hanūmān, Garuḍa, Aśvins, Pitṛs, Apsarases, Saptarṣis, Ekādaśarudras, Kṣetrapāla, Vāmana, Nṛvarāha, Nṛsimha, Trivikrama, Matsyamūrti; Kūrma, Brahmā, Kumāra, Nāga, Asuras, Dānavas, Piśācas, Vetālas, Grahas, Gṛdhras - verses related to these deities are cited here.

Chapter 27 presents the descriptions of elevated seats, etc, padmapīṭha, nāḷa, definitions of image, phallic image and elevated seat are dealt with first (XXVII. 1, 3 and 4). Then the author gives the measurements and other details of elevated seats in nāgara, vesara and drāviḍa; merusundara, lakṣmīsundara, viṣṇusammilana, padmabhadra, samāṅgabhadra, rudrakānta, somakānta, sarvāṅgabhadraka, śrīkara, puṣṭivardhana, saumya, the construction of the seat of Śivaliṅga, the division of the parts of the elevated seats, nāḷa, base stone, brahmaśilā like nāgara, different seats accroding to place and sitting posture - these are also dealt with here.

Chapter 28 enjoins the rules and regulations of the installation of images. Rules of installation; construction of pots, etc, for sowing seeds; definitions of pālikā, ghaṭikā and śarāva; the height of elevated seats; fire-vessels in the form of square, yoni, half-moon, triangle, circle, hexangular, eight-petaled and octagonal: characteristics of the pots, namely, sruva, juhū and mahāsruk, bhadraka, cakrābja, śaktidaṇḍa, ṣaḍdala and svastikābhadra; the rules for installation etc; installation of idol with that of elevated seat - these topics are treated in this chapter.

Renovation is the subject matter of chapter 29. The construction of a temporary small shrine, niṣkrāmaṇa and saṅkocana are dealt with here as part of the renovation. Chapter 30 describes liṅgaprāsādavidhi.

The content of chapter 31 is the construction of residential building. Suggestion of the content of the present chapter, rules regarding the length and breadth of the base according to different castes, construction of fence, rampart, etc; fixation of sūtra and street etc; yoni and the like, construction of houses with two halls, three halls and four halls; varieties of halls; construction of door etc, and buildings nearby the main one; measurement of daṇḍa and dvāra; construction of a house having four halls in a different way; sixteen types of houses; construction of various kinds of royal residences according to number and measurement of pillars; construction of buildings around the royal house; oblations to vāstu; house warming of kings - these are described in this chapter. Chapter 32 deals with the problem of well. The next chapter contains the definitions of paraphernalia like seat. Construction of seat, fan, umbrella, bed, five vechicles, namely, palanquin, sukhāsana, chariot, boat and raft; eight kinds of bed, pillow, shoe, measurement of kuṭuba etc; mortar and the like, balance, oval vessel filled by oil, water machine, sugar cane machine, nadīyantra and golden wedge is described in this chapter.

The wage-rate of labourers is the content of the next chapter. Knowledge of the value of a khaṇḍī of wood, wage for sawing, tearing, chiseling and polishing, wage for making of idols and the like, wage for making of metal ornaments and the like - these are the contents

of chapter 34. The last chapter of Part II, i.e., chapter 35, deals with the construction of weapons. Making of bow is mainly described here.

From the above description, we may come to the conclusion that *SR* is a milestone in the field of Kerala architecture and iconography and that the study of the work will yield, to a large extent, the result similar to that of the study of *TS* and *MC* together.

Mention may be made in this connection on a short tract by name *Bhāṣāśilparatnam*[8]. This is an abridged Malayalam version of *SR*. The first part of it contains 550 verses and deals with temple architecture. The second part has only 59 verses and describes the construction of residential buildings. It is this short Malayalam version of *SR* that had been used by traditional carpenters for the last few centuries.

Appendix

List of verses in *SR* identical with those in *TS*, *MC* and SS

SR **Part I**	1. 30	*TS*	1.5
	3. 1, 2		1.30, 31 (MC 1.17, 18)
	3. 5-8		1.41, 39, 40, 42
	3. 14, 16		1.32, 33
	3. 17	*MC*	1.32
	4. 4		1.54
	7. 64		1.70
	9. 1, 2		1.28, 29
	9. 16		2.2
	10. 4, 9		1.59, 12.3
	11.17		12.2
	1. 22		12.23
	12. 11		12.6
	12. 24		12.4
	12. 34		12.5
	14. 10,11,15		1. 132,131,133

15. 12	2.5
16. 2,4,29-31,36,51	2. 1,7;62-64,55,71
17. 11,12,23,27,32	2.8,9,57,11,12
19. 39,74,75,116	2. 14-16
20. 1, 2	2. 21, 22
21. 1-4, 16, 18, 21, 41, 51 (twice) 52,75	2.21,22,17-20,36, 37, 43, 38(2), 23-25
22. 1-3, 25, 29, 38, 95, 100,104	2. 27-30, 26,31,32,34,33
23. 1,29,33-35	2. 35; 12. 22; 4. 65-67
25. 1, 5	2. 39, 40
26. 2	2. 41
28. 1	2. 42
29. 1,7,31,32	2. 44-47
30. 2	2. 53
31. 15-18	2. 58-61
33. 1,57,64	2. 48-59
36. 7	2. 54
37. 2	2. 52
38. 3,6,11,14-16	2. 65-70
39. 1,13	2. 72,76
40. 4,8,14,15	2. 81,85,83,84
44. 11	6. 136
SR Part II	***TS***
2. 14,18,19,66, 67,77,78,	2. 121,119,120,122-125, 128,126,127
3. 8-10	2. 129-131
4. 1,18,30,31,52	2. 85; 12. 12; 2. 138,139,87
6. 6-8	2. 112-114
9. 1-21	2. 88-108
14. 29	2. 115

16. 1,65,66	2. 109,117,118
22. 180	7. 66
24. 2	7. 68
24. 4,76-85 *SS*,	3.103(with some changes), 3. 110-116,107-109
25. 57,68,79	7. 70,71,67
27. 1,3,4	2. 117,118,132
27. 46,49,62-64	2. 133-137
28. 4-11, 14-29,30-45, 49,50,55-57	12. 13-20, 24-39, 41-56, 7-8, 9-11
29. 1,2,10,34	11. 1,110,2,88 (also *SS*. 6. 94)
31. 22,23	*MC*, 2. 16,18 (also 7.23)
31. Babc	*MC*, 7. 16 abc
31. 19ab	*MC*, 2. 7b
31. 74a	*MC*, 7. 15a

References

1. Part I (ed) by T. Ganapati Sastri, Trivandrum, 1922; Part II (ed) K. Sambasiva Sastri, Trivandrum, 1929.
2. Ed. T. Ganapati sastri, reprint, Nag Publishers, Delhi, 1989.
3. Ed. Chandrasekhara Pillai V and Balakrishnan Achari S, Trivandrum, 1979.
4. With an Engineering commentary by Dr. A. Achyuthan and Dr. Balagopal T.S. Prabhu, Vastuvidyapratisthanam, Calicut, 1998.
5. Vidc colophon to *SR*, Part I, p.258 and the verse I.1.7.
6. *Ibid.* I.1.4.
7. *SR* reproduces several verses from TS, MC and *Śeṣasamuccaya* (*SS)* (Published with *Vimarśinī* from Trivandrum, 1952). For a rather comprehensive list, see Appendix.
8. Ed. by Balakrishnan Achari, Trivandrum, 1976.



Bṛhat Samhitā

P. Manoharan

Varāhamihira holds a unique position in the history of science and technology in ancient India. He lived in 5th century A.D. His magnum opus *Bṛhatsamhitā* is really an encyclopedia of astronomical and other subjects of human interest.

Varāhamihira composed works in all the three branches of jyotiṣa viz; gaṇita (mathematics), horā (astrology) and samhitā (astronomy). His *Pañcasiddhāntikā* comes under the first branch. It summarises the five siddhāntas current in his time, namely pauliśa, romaka, vāsiṣṭha, saura and paitāmaha. Utpala's commentary on *Bṛhatsamhitā* contains a large number of quotations from *Pañcasiddhāntikā*. Varāhamihira's works in the other two branches are available in a double form *Bṛhat* (elaborate) and Laghu (abridged). *Bṛhajjātaka, Bṛhadvivāhapaṭala and Bṛhadyātrā* along with their abridged versions, the *Laghujātaka, Svalpavivāhapaṭala* and *Svalpayātrā* belong to the second branch. In addition, he has composed *Yogayātrā*.

Bṛhatsamhitā is the master piece of Varāhamihira and it is really a product of his accumulated experience. Utpala, the commentator thereof modifies his style as svalpam vṛttavicitram arthabahulam nātilaghuvipularacanāni and called him as jyotiśśāstrasaṅgrahakṛt. The term samhitā means compilation. As such it cannot be an original work. It should therefore include details of many subjects found in various works. *Bṛhatsamhitā* forms an ideal example for samhitā literature. Here what Varāhamihira did in *Bṛhatsamhitā* was to restore

the scientific tradition followed by his ancestors in the light of his own scientific outlook for the posterity of human generation.

Scientific Tradition of Bṛhatsamhitā and its Modern Relevance

The greatness of Varāhamihira lies in the fact that he explores in depth of the secret of nature and finds out practical ways for the welfare of human progress and for the advancement of civilization. His intention to write such a samhitā may be to apply his knowledge of science for day to day life. That is what is seen in the upāṅga portion of *Bṛhatsamhitā*. While the aṅga portion of the text which consists of astrology and astronomy is purely theoretical and observational, the upāṅga portion is more related to practical life.

Various topics of scientific interest are systematically and methodologically arranged in *Bṛhatsamhitā*. A separate chapter of the text titled as Śāstrānukramaṇī indicates his own methodology in arranging the topics to be investigated.This treatise may be regarded as a primary contribution of physical and biological sciences, engineering, sculpture and medicine. This practice was followed by King Bhoja of Dhara in Malva (A.D.1019-62), the author of *Sarasvatīkaṇṭhābharaṇa, Yuktikalpataru* and *Samarāṅgaṇa - sūtradhāra,* and by King Someśvara, the author of *Mānasollāsa* (12th century A.D). This shows Varāhamihira's scientific and technological influence on the subsequent generations.

What Varāhamihira did in *Bṛhatsamhitā* is that he connects all the phenomena discussed in the text with jyotiṣa which comprehends a general collection of astrology and astronomy. Astrological perspective is seen in various scientific branches like engineering and applied medicines. Further he adopted an integral method of approach for finding solutions to the problems to be investigated. An elaborate chapter in the text titled as dakārgala which is considered as an interdisciplinary faculty of vāstuvidyā proves this fact. It primarly deals with various geological and biological characteristics as indicators for location of underground water veins.

Here in the methods of finding underground water based on the physical feature of earth brings out the importance of the preservation of biodiversity as part of water conservation and for the location of ground water resources. Varāhamihira describės in detail the bio-geographical factors as water indicators. An example may be cited here: If there be an ant-hill to the north of an arjuna tree there would be water at the depth of 17 $^{1}/_{21}$ cubits at a distance of three cubits to the west of the tree. Here the signs are that at a depth of 2 cubits there will be a white alligator, there at a depth of five cubits, grey clay, then dark, then yellow, then white and then sandy earth and beneath that abundant water will be found.

This is very relevant in today's context. Several crores are being spent every year for introducing digging technology without getting the idea of bio-factors as detailed in the text.

The information furnished in *Bṛhatsamhitā* proves that Varāhamihira travelled almost all over India as well as abroad and collected data related to geographical matters, tribal life, botanical informations and species of animals, birds and fishes. The chapter titled as śakuna and virutam, though dealing with omens connected with astrology are really treasures of knowledge connected with the different species of birds, animals, reptiles and fishes. Here Varāhamihira furnishes details of birds and animals as a natural scientist.

Varāhamihira's regard for nature is reflected in most of the topics of *Bṛhatsamhitā.* Chapters titled as kusumalatādhyāya and vṛkṣāyurveda respectively speak of natural methods of confronting economic problems.The introduction of herbal fertilizer and some kinds of herbal pesticides as mentioned in the vṛkṣāyurvedādhaya of *Bṛhatsamhitā* is an asset for modern agricultural scientists and technologists especially in the context of the harmful side effects of chemical fertilizers and pesticides. The relevance of vṛkṣāyuveda topics of *Bṛhatsamhitā* lies in the fact that several traditional agricultural practices which are of contemporary relevance would be brought to light for better yield. A detailed study of the botanical portions of the

work will enable us to gain knowledge of plants and plant life and can provide insights for solution to several current day problems. E.A.V. Prasad observes: "In view of the paramount importance of agriculture in Indian economy, detailed and systematic investigation of Varāhamihira's phonological indicators in modern context applicable to different regions should be undertaken by different agencies such as the Indian council of Agricultural Research, Agricultural Colleges and Universities, Departments of Forestry and the Remote Sensing Division of the Indian Space Research Organization (I.S.R.O) to achieve rapid results in agriculture production".

All these facts highlight the scientific importance of *Bṛhatsamhitā* and its modern relevance in the light of scientific investigations.



Town Planning in Ancient India

Anandakrishnan Kunholathillath

The subject of town-planning was treated as a part of vāstuvidyā or the science of habitation in ancient India.Town-planning is given due importance even during the Vedic period.This science can be more clearly seen in Purāṇas and Itihāsas.

According to Indian mythology Viśvakarmā and Maya are the two great architects or town-planners of Gods and demons respectively. Alakāpurī, the capital city of Gods and Laṅkāpurī, the city of Kubera, were planned by Viśvakarmā. Likewise the story of Tripura says that these cities were built by Maya.These three cities were belonged to the demons and were tightly secured by heavy walls.These stories indicate the antiquity of the concept of Indian town-planning.

The escavations of Mohan-Ja-daro and Harappa also prove the knowledge of city planning of Indians.

Indraprastha, Ujjain, Pātalīputra, Ahicchatra etc were the old big cities of India. Rampart, roads, public buildings, drainage systems etc were the common features of these cities.

Some towns grew up spontaneously, but others were built systematically. In a planned city, there were some basic principles of city planning, which can be observed and were strictly followed in their constructions.

There were some common features in the construction of towns and villages in India from ancient time onwards. At the centre of the city, there was a main temple in the form of grāmakṣetra. All types of cities were surrounded by a wall and beside this there may be a ditch. परिखा - परितः परिखां बाह्ये कुर्यात् *(Mānasāra)*. It protected the city from an attack. There were two main roads running from east to west and north to south.There were four main gates at the end of the main roads in the middle of the outer wall to the four directions. Building such as hospitals (वैद्यालय), colleges (गुरुमठ), libraries, resthouses (सत्रालय) etc were also the peculiarities of ancient towns. Generally people of the same profession were housed in a particular area only. Beside the main street there were many other roads which divide the site as plots. Houses are built on both sides of the streets .

Selection of Site

Before building a new city or village, the selection of land is very important. Vāstuśāstra gave great importance to the selection of a proper site for founding a new village or town. The location is finally selected only after a careful study of soil, environment etc.

Sites are generally classified under three catergories, viz, jāṅgala, ānūpa, and sādhāraṇa.

Jāṅgala is a barren land, where a steady and dry wind blows which is not suitable for founding a city. *Kāmikāgama* describes it thus:

स्थिरं गुरुतरं भूरिशर्करं क्षारवारिणा ।
युक्तमल्पीयसात्यन्तं खाते गन्धेऽपि जाङ्गलम् ।।

Ānūpa is mostly abounding in rivers and other water resources. It is swept by cold wind and suited for the construction of new city.

कशेरुकैरवाकीर्णं रूढसौगन्धिकोत्पलम् ।
सूक्ष्मवालुकमानूपं कृषिकृत्युच्चलज्जलम् ।। *(ibid)*

A site where the qualities of jāṅgala and ānūpa are intermingled is called sādhāraṇa- जाङ्गलानूपसंमिश्रगुणं साधारणं स्मृतम् *(ibid)*. It is neither

good nor bad.

Types of Town

Mānasāra of Mānasāramuni classifies town into eight types according to their shape and method of street planning. They are daṇḍaka, sarvatobhadra, nandyāvarta, bhadraka or padmaka, svastika, prastara, kārmuka and caturmukha.

Aparājitapṛccha of Bhuvanadeva describes twenty types of cities having their peculiar shapes: mahendra, sarvatobhadra, simhāvaloka, vāruṇa, nandyāvarta, nanda, puṣpaka, svastika, pārśvadaṇḍa, jayanta, śrīpura, ripumardana, snaha, divya, uttara, dharma, kamalada, śakrada, mahājaya and pauruṣa. *Viśvakarmavāstuśāstra* also describes twenty types of cities.They are - padma, sarvatobhadra, viśveśabhadra, kārmuka, prastara, svastika, caturmukha, śrīpratiṣṭhtita, balideva, pura, devanagara, vaijayanta, purabhedana, jalanagara, guhānagara, aṣṭamukha, nandyāvarta, rājadhānī, mānuṣanagara and girinagara.

Mayamata of Gannammacharya gives importance on street planning and classifies the cities into eight types called daṇḍaka, svastika, prastars, prakīrṇaka, nandyāvarta, parāga, padma and śrīpratiṣṭhtita.

Bhoja's *Samarāṅgaṇasūtradhāra* and Kauṭilya's *Arthaśāstra* also describe the cities, fortification etc.

Śilparatna of Śrīkumāra is a sixteenth centuary work, which deals with the construction of houses, villages or cities and other allied subjects in its first part. According to Śrīkumāra towns or villages are of fourteen types: grāma, kheṭaka, kharvaṭa, durga, nagara, rājadhānī, pattana, droṇikāmukha, śibira, skandhāvāra, sthānīya, viḍambaka, vigama and śākhānagara.

Beside these, Āgamas like *Kāmika* and Samhitās like *Padma* also give details about this subject. Different works of different periods portray different types of towns according to their shape, street planning etc. Among these *Mānasāra* is the most scientific, popular, and so considerable. As mentioned above daṇḍaka, sarvatobhadra,

nandyāvarta, padmaka, svastika, prastara, kārmuka and catur mukha are the eight types of cities dealt with in the ninth and tenth chapters of *Mānasāra*.

1. Daṇḍaka

The town called Daṇḍaka is rectangular in form and possesses a rampart and moat surrounding it. Usually the daṇḍaka town has two main entrance ways but may also have four. In this type of town planning, temple is not in the northern region.The shrine of a female deity such as grāmadevatā in the form of Mahākālī or Durgā should be built near the north gate, outside the wall. It consists of one to five parallel streets running generally east to west.The streets are lined with a double row of houses. Market and bazarlines will be located in any suitable places for the convenience of the residing inhabitants. The south-west of the city housed the hermitage of saints and gardens. The reservoir of water should be erected on the east and the lake should be on the west.

2. Sarvatobhadra

This is square in form. In the centre of the city should be located the temple. Outside of the wall there is also a temple of Goddess as in daṇḍaka.Two large streets will be running east to west and north to south in addition to several other roads. At the junction of four streets are built resthouses for travellers. The residence of purapālaka or the Police should be built near it. Merchants, carpenters, goldsmiths, coppersmiths and other workmen should live in the south and the houses of dhobies, potters and barbers should be located on the south-east. College should be erected on the north-west and the hospital on the south-west.The water shed should be built in the south-east corner of the city. The city will be secured by a wall with four gates and a ditch.

3. Nandyāvarta

The site of nandyāvarta town may be either circular or square in shape.The town is surrounded by a wall and a ditch.The circular site is divided first into four quadrants by two large streets. The temple of

God Viṣṇu or Śiva will be in the centre of the site at the innersection of two main streets. In each quadrant from three to seven streets are laid out with a row of houses on each side.

Colleges should be located on the north-west of the city and hospital on the west. The palace, court of justice and all other state buildings are located in the western side. Tank and hermitage are near to the temple and theatre should be on the east.The whole plan should contain not less than three thousand houses, but not more than four thousand. There are four main gates and they shall be located near the four corners in the case of a square type.

4. Padmaka

This type of city used to be practically in an island surrounded by water. The whole town should be surrounded by a fort-wall.The padmaka type town is laid out in four different types, ie, having four corners and faces.There should be gates in four directions. The temple is to be constructed at the centre of the city. Tank is near to the temple; and the palace is located in the northern part. All public offices should be close to the palace. Shops and vegetable stalls are built in the eastern side and meat market in the west. The place alloted for shops for other articles is the southern part of the city.

5. Svastika

The site may be either square or rectangular in form. The town is protected by a wall with a moat at its foot, filled with water. Like in the other types of town, in svastika also the main temple is located at the centre of the city with streets around it. There are two main roads crossing each other at the centre of the city and running east to west and south to north. There are eight main doors and out of them four entrances are large and they lead to the two main roads of the city. These entrances are closed by strong double doors and secured by strong iron bars. The royal palace should be erected in the west of the town and prince's palace should lie just opposite to it. Court of justice and other Government offices should be located near the palace. On the east of the city is placed the temple of Sarasvatī; and the temple of

Jains should be located in the south-west only. Shrines of Gaṇeśa and Kālī are placed near to the four main entrances. It is said that this type of town is specially suited for kings because of its protective devices.

6. Prastara

According to the *Mānasāra* description, this type of town is either square or oblong in form. The town is enclosed by walls and ditches with four gates. In this plan the main roads are much wider compared to those of other patterns. The temple of God Viṣṇu or Śiva will lie in the centre of the site and a tank very near to it. Colleges and hospitals should be located in north-west and south-west part of the city respectively.

In this plan, allotment of plots for people is treated in a different manner.The whole site will be divided as four equal wards firstly for the different classes of people.This distinction in the division is accounted for by the degrees of rank and wealth of the persons that are to occupy the ward.

The ward of the poorest classes is divided into 36 equal blocks while that of the middle classes is divided into 25, that of rich into 16 and that of the very rich into 9 blocks only.

7. Kārmuka

The plan of this type of town resembles a bow, as the name suggests.This plan is adopted in the place where the site of the town is in the form of a bow or a semi-circular form. The kārmuka plan is generally suited to a river bank or sea-shore. There are three such classes in this type, viz : kārmukapura, kārmukakheṭaka and kārmukakhaḍga.

Long streets lined with rows of large and lofty houses, extensive bazarlines and temples are the peculiarities of kārmukapura.

Kheṭaka is generally inhabited by painters, artists and other workmen with their workshop.

According to *Mānasāra* the main streets of kārmuka town run from east to west or north to south. The streets are mostly lined by

houses on both sides. The temple of male deities should be built in the centre of the town on the main street. This type of town is commonly presided over by female deities also. This may be built in any part of the city.

8. Caturmukha

This is the last type of town, which *Mānasāra* canonizes. This is square or oblong in size. It is laid out east to west long wise. There are four big streets on the four sides inside the outer walls and two main roads running north to south and east to west,which are intersecting each other at right angles in the centre. The temple should be located in the centre of the city. There are four main entrance ways at the end of the streets to the city wall.

After the Western rule in India, we are following the western concepts in town-planning also like in other fields. But, all these show our contribution in architecture espicially in town-planning like other branches of science such as astronomy and medicine.



Vāstuvidyā and Ecology

C. Rajendran

Vāstu, which is derived from the Sanskrit root 'vas', meaning 'to dwell' stands for dwelling apartments in a strict sense, but the term vāstuśāstra generally signifies architecture in Indian tradition. Here the term is used in the sense of India's tradtional architecture especially as it developed in Kerala, where it is still practised. India has a continuous history of architecture from at least the time of Indus valley civilization, with different styles varying from time to time and place to place. Unfortunately, with the advent of modernism and the consequent massive urbanization, we have at present lost much of our tradition. New building styles and techniques have replaced the old ones. Consequently, we now lack a living tradition of our vāstu practices in many places of our country, which had made use of the natural resources abundant in the country and which had eco-friendly configuration. Now when the very agenda of modernity has come under sharp scrutiny in the post-industrial and post-modernist scenario, the tenets of vāstuśāstra have acquired a new significance. They have proven their vitality and worth down the centuries while we are yet to assess the full impact of the modern concrete jungles on the already fragile environment. Here, an attempt is made to look into vāstuśāstra from an environmental perspective.

Almost all treatises on vastuśāstra prescribe elaborate guidelines

for the selection of a proper site for the cunstruction of the dwelling house. This is in stark contrast with the modern practice of building houses in any place irrespective of the nature of the terrain. True, the problems created by rapid urbanisation do not leave much choise for us in the selection of site in modern times, but the prescriptions in ancient treatises should serve as some sort of guidelines for the modern town planners. Ancient treatises like *Padmasamhitā* classify the terrain into four, mainly on the basis of the nature and locatoin of the site. Accordingly, the land situtated near sea, river etc. which abounds in water is called bhadrā. It is ideal for the construction of house, as it is conducive to the growth of plants and trees. Pūrṇā is the name given to land on hillside favourable for the construction of dwelling houses. Supadmā is the land in plains, also favourable for residential purposes. On the other hand, the land called dhūmrā has extreme climatic variations and rocky surface. It does not have enough water and also abounds in wild animals as well as poisonous plants. Needless to say, such land is not ideal for residence.

According to texts like *Manuṣyālayacandrikā* and *Śilparatna,* ideal site should be rich with cows, human beings, flowering, fruit-bearing and sappy trees, of even level, sloping to the East, smooth, producing good sound (when walked upon), with water flowiing on clockwise direction. It should cause speedy germination of seeds, be compact, having perennial water and even in heat and cold. The land deficient in these qualities is bad, and that with mixed character is mediocre for settlement purposes. The land which is irregularly shaped and which is full of ashes, cinder, husk, bones, hair, vermin and anthill is also not recommended. Also, the land should not be concave in surface, foul smelling, and unmatching to the four cardinal directions. Land which is muddy, scorching in the sun, infested by pests, having scarcity of water, inhabited by demons, low-lying and rocky should also to be avoided. These stipulations seem to have been made to ensure that the land is rich in its biodiversity and conducive to the growth of trees and plants as well as friendly to animals. The stipulation that the site should be sloping to the eastern direction seems to be to ensure the availability

of plenty of sunshine in the early morning. The requirement that the site should be smooth and should produce sound when walked upon was to ensure certain firmness for the ground.

Śrīkumāra, the author *of Śilparatna,* gives the following details of the division of soil:

Name	Trees and plants	Nature of soil
pūrṇā	plakṣa, nyagrodha, nimba, arjuna, bakula, aśoka, aṅkola, mālatī, campā, khadira, kodrava	plenty of water, high - lying, suitable for residence
supadmā	karpūra, aguru, coconut, sugrcane, tilaka, kadamba, arjuna, sandal, arecanut, ketaka, kuśa, jasmine, lotus	abounds in water.
bhadrā	paddy, similar grains, trees used for sacrificial purposes. Fruit trees and flowering trees.	fit for sacrificial priests
dhūmrā	arka, bamboo, vibhītaka	rocky, thick, full of holes, dry, frequented by birds like hawks. Not ideal for sacrifiers

Another classification of soil is the following:

Name	Features
vāruṇī	tender trees, flowering forests, full of lakes
aindrī	sappy trees, plenty of water, paddy field
āgneyī	scarcity of water, presence of vultures, pigs, foxes, crows
vāyavī	arid soil, full of cactuses and the like

Availability of plenty of water and the provision for wastewater disposal are two other important points stressed in

Manuṣyālayacandrikā. The work makes it clear that only places with perennial supply of water are fit for human habitation. Again, water should ideally flow in a clockwise direction, though the full implication of this stipulation is not known.

Environmental considerations are again implicit in the prohibition of certain types of sites and soils to be used for building houses. Thus, land having the presence of ash, cinder, husk, bones, hair, vermin and anthill are not regarded as ideal. The reason seems to be that they must have been used for sacrificial purposes or as burial ground or dumping ground. Vermin and anthills are not good signs since they indicate the presence of termites and pests, which will be detrimental to the wooden and similar parts of the house. Land with concave surface is to be avoided, as it will have no capacity for wastewater disposal. Land with foul smell is to be avoided as it indicates degraded environment.

Most of the treatises on vāstuvid*yā* maintain that all constructions should be oriented to the cardinal directions. In fact, an onlooker passing through highways in places like Kerala can readily see that most of the conventional buildings, constructed on traditional style are oriented to directions and not to the location of roads and the like. The reason seems to be the importance attached to the position of sun. Maximum presence of sunlight was ensured in houses at any cost. For this, the position of the sun in the uttarāyaṇa and dakṣiṇāyana transits was taken into account. The climatic change resulting from the elliptical movement of the sun was also taken into consideration.

Manuṣyālayacandrikā and similar treatises give utmost importance to the plantation of various types of trees in different parts of the compound.

Bakula (Mimusops elengi) and banyan tree (Ficus bengalensis) in the east and udumbara (F. racemosa) and tamarind (Tamarindus indica) in the south will bestow prosperity. In the west, aśvattha (F. religiosa) and saptacchada (*Alstonia scholaris)* and in the north, nāga *(Mesua nagassarium)* and plakṣa (F. microcapra) are prescribed. Jack tree (Atrocarpus heterophyllus), arecanut palm (Areca catechu), coconut

palm (Cocos nucifera) are especially propitious in the directions of east etc. (east, south, west, north) respectively.[1]

The rich insight on biodiversity of the land implicit in the above prescription is significant. The verse has the vision of dwelling house which is surrounded on all directions by fruit-yeilding and medicinal trees, which add to the prosperity and well being of the people. It also naturalizes the surroundings and removes any alienation felt by the people. Plants have also a cooling effect on the environment and they ensure plenty of oxygen to the poisonous trees like kāraskara (Tsrychnos nux vomica). Auspicious trees prescribed include śrīvṛkṣa (Gmelina arborea), bilva (Aegle narmelos), abhaya (Terminalia chebula), vyādhighna (Cassia fistula*)*, āmalakī (Phyllanthus embilica), suradruma (Cedrus deodor), palāśa (Butea frontosa), aśoka (Sraca asoca), māleyaka (Santalum album), punnāga (Calophyllum inophyllum), asana (Pteroccarpus narsupium), campaka *(*Michellia champaka*)*, *khadira* (Acacia kadali) (Musa sp), jāti (Myristica fragrans) and nāgalatā (Piper betel).

The types of trees to be plantd are also dependent on the nature of the core. Accordingly, *Manuṣyālayacandrikā* makes a fourfold classification of trees, viz, antassāra (hard-core) like jack tree, *sarvasāra* (throughout hard) like tamarind and teak, *bahissāra* (strong outwards) like palm, coconut etc and nissāra (softwood) like śigru. The first types should be planted in the inner circle surrounding the house, followed respectively by the other three types. The reason for this seems to be the fact that during heavy rainfall and wind, soft plants have every chance to fall down and thereby cause damage to the structure.

We do not know the full significance of the prescription of certain trees at certain positions of the compound. However, it is clear that both environmental and ritualistic considerations must have been behind them. According to Achyuthan and Balagopal Prabhu, *Manuṣyālayacandrikā* prescribes southern direction for trees like areca, having very little foliage and tamarind, which sheds its leaves in winter in order to ensure the availability of sunshine in winter season[2]. Such

trees will not block the sunlight coming from the south in winter due to the dakṣiṇāyana movement of the sun. Similarly, trees with thick foliage were to be planted in the North, as they would be helpful to resist cold wind coming from the North.[3] It seems that ancient works on vāstuśāstra were aware of the ecological problems caused by the pressure on land due to unbridled construction work. This is evident from the zonal restrictions for residences near paddy fields, mountains, temples, oceans, rivers, hermitages, and cattlesheds. We also find areas earmarked for residential purposes in works like Kauṭilya's *Arthaśāstra* very much similar to modern practices in town planning followed in the developed countries.

A unique feature of Indian residential architecture is the concept of vāstupuruṣa, the mythical demon, whose body symbolically represents the site on which the buildiing is built. Vāstupuruṣa essentially typifies on organic model, wherein the human edifice is conceived as an extension of the life force of the universe. This is in accordance with the ancient Indian notion of man as a part of the grand cosmic scheme and sharply contrasts with the European concept of mechanical structures, which are thrust on nature. There are sensitive areas in the body of vāstupuruṣa, which cannot be tampered with in the construction of the building in Indian vision. Though the immediate scientific principle of such prescriptions is not known, it reinforces the basic notion of an environment-friendly approch to nature and life. Treatises like *Manuṣyālayacandrikā* prescribe adequate precautions in house construction to ensure ventilation and privacy and to avoid overcrowding. Thus, it is prescribed that the plot is to be sub-divided into four quadrants. The north-east quadrant called mānuṣakhaṇḍa is recommended as the ideal location for the actual building, which will bring prosperity. The south-west quadrant called devatākhaṇḍa is also good. This zonal restriction ensures that there is some gap between one house and the other. Again the outer vīthi of the plot, called piśācavīthi was supposed to be unfit for construction, for the obvious reason that the distance between one house and the other will be less.

Eco-aesthetic considerations are also implicit in the unique

conception of an inner quadrangle (atrium) opening to the sky, in the middle of the house. In this construction, the courtyard ensured that there is proper ventilation and sunlight available to the inner parts of the house without unduly compromising security. Atrium was a ritualistic area also, as it served as the place where some important rites were performed. Provision was also made for jasmine creepers to grow in the atrium, which ensured the splendour and fragrance of flowers within the house, also providing the most necessary touch of nature to human life. This is a legacy of the past, which we have sadly missed in our apartment life of modern times.

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Ecological Awareness in the Vedas

C. M. Neelakandhan

On 4th March 1969, some students of technology in American Universities deserted their classes to protest against those branches of knowledge which aim at threatening the survival of human beings in the Universe.Their main protest was against the tendency of man to use the nature's resources in an unlimited manner. They argue that this will cause the complete destroyal of nature's resources and finally become a threatening to the existance of humanity in this Universe. Actually this protest was the culmination of the awareness of modern man that tempted him to question the sanctity of modern science. As a result, a new branch of knowledge came into existance called 'environmental science' or 'ecological awareness'. This branch lodged in 'nurture nature' motto and includes in its scope all scientific attempts aiming at studying, nurturing and utilising nature without disfiguring her.

The thoughts on environmental studies and ecological awareness have got wide acceptance all over the world today. The organisations like Sastra Sahitya Parishad in Kerala and India give much stress to this aspect also as one of their areas of activity.

This environmental awareness is a reaction to the environmental chaos caused by the selfish technological developments. Today people are actually suffering from problems such as pollution, undue growth in population, imbalance in environmental cycles etc. But we can find

that ancient people belonging to various cultures were showing much concern to the environment in which they breath in, though not with the full awareness of it as is conceived now. India also, from the time of the Vedas, has propagated such thoughts through ancient texts like the Vedas, Brāhmaṇas and Sūtra texts, a glimpse to which is the subject matter dealt with here.

The main factor which prompted or promoted the ancient seers to show such a kind of preventive awareness is the attitude of human beings towards nature. This attitude is based on the relationship between man and nature. What a person thinks of himself in relation to the things around him, decides the attitude. If a person thinks of himself to be the master of the Universe, he will rule over all things. If he thinks to be a small part of the multi-varied, infinite, variegated, wonderful Universe, he will know the pains of other beings and wish the well being of them. The Vedic seers had this feeling. This is widely connected with the tenets of different philosophical systems like Sāṅkhya, Yoga, Nyāya,Vaiśeṣika, Mīmāmsā and Vedānta and heterodox systems like Buddhism, Jainism and Lokāyata or Cārvaka developed in India from very ancient times.

It is noteworthy that man in the Vedic age treats himself as a part of nature.The fact is well evident in the creation of myth. It is said that the whole world is a creation of Yajñapuruṣa. He has created the earth, air, water, light, space etc. from his body. Also he has created various creatures like horse, goat etc. Along with these, he created human beings also. Here we do not find any special concession given to human beings to surpass or master other factors. He is treated at par with all other things in the Universe. That is why in *Yajurveda* man wishes the well being of other creatures and plants along with that of himself. In a verse, he describes lord Rudra as medicine for cow, horse, goat and for human beings:

भेषजमसि भेषजं गवेऽश्वाय भेषजम्
मुखं मेषाय मेष्यै मानुषीभ्यश्च ।

Śuklayajurveda (SYV), 3.5.

In another verse, he wishes the well being of earth and heaven, ether and plants. He does not want these to be destructed:

शिवो भव प्रजाभ्यः मानुषीभ्यस्त्वमङ्गिरः ।
मा द्यावापृथिवी अभिशोचीः मान्तरिक्षं मा वनस्पतीन् ।।
SYV,11.45.

While he cuts trees even for the yūpa (sacrificial post), he thinks that the falling yūpa should not harm heaven and earth:

द्यां मा अभिलेखीः अन्तरिक्षं मा हिंसीः । *SYV, 5.43*

In a hymn in *Ṛgveda*, water, air, trees and medicinal plants are invocated along with Gods like Indra and Mitra:

तन्न इन्द्रो वरुणो मित्रोऽग्निः
आप ओषधीर्वह्निनो जुषन्त ।
शर्मन् स्याम मरुतामुपस्थे
यूयं पातस्स्वस्तिभिस्सदा नः । *Ṛgveda, VII.34.27)*

Water Resources, Purity of Water

Water is one of the most essential factors for life in this world. People from very ancient times were aware of its importance. One of the epithets for water in Sanskrit is जीवनम् (that which gives life) and other is अमृतं (nectar) which again conveys almost the same sense. Another hymn says that water contains nectar, all medical properties and the auspicious fire that gives prosperity to the Universe:

अप्स्वन्तरमृतमप्सु भेषजम्
अपामुत प्रशस्तिभिर्देवा भवथ वाजिनः ।
अप्सु मे सोमो अब्रवीदन्तर्विश्वानि भेषजाः
अग्निं च विश्वशंभुवम् आपश्च विश्वभेषजीः ।।*Ṛgveda,*1.23,19.20

The same hymn, with slight difference, is found in *Atharvaveda* also (I.1. 4.4)

Ṛgveda X. 75 describes rivers. Many rivers are mentioned there

by name with their characteristics. It is said that some rivers are pravātas (that flow through slanted areas), some as nivātas (that flow through low lands) and some udvātas (that flow through upper parts like the tops of hills and mountains). This shows that the Ṛgvedic seers had some geographical concepts regarding the nature of rivers.

Ṛgveda VII. 49.2 describes different kinds of water sources which again contain some scientific notions. According to the hymn, water sources are of five kinds. Divyāḥ (that are got from the sky, ie.from rain), sravantīḥ (that are produced from springs), khanitrimāḥ (that are made by digging earth like well and ponds), svayamjāḥ (that are born naturally like lakes and seas) and samudrārthāḥ (rivers that flow to join the oceans).

There was much caution against the pollution of water also. In *Taittirīyāraṇyaka,* it is stressed that one should not excrete or urinate in water, one should not spit or take bath without any cloths on the body - नाप्सु मूत्रपुरीषं कुर्यात्, न निष्ठीवेत्, न वा विवसनः स्नायात् (*Taittirīyāraṇyaka,1.26.5.7).* Vedic seers may be taking caution against various contageous diseases that may spread through water by excreting in it or spitting or taking bath naked.

Hymns on Sun God

There are many sūktas in *Ṛgveda* that praise the greatness of Sun God. Some hymns mention certain powers of Sun which seem to have some scientific implications that have been accepted by modern advocates of naturopathy. It is said that the rays of Sun have the power to cure dangerous skin diseases. In the Vedic hymn it is named harimā (some kind of dark green colour which is the colour of skin when deep and decayed wounds spread all over the body) which may be some disease like leprosy. Sun rays have the power to cure it:

उद्यन्नद्य मित्रमह आरोहन्नुत्तरां दिवम् ।
हृद्रोगं मम सूर्य हरिमाणं च नाशय ।। *Ṛgveda,1.50.11*

Oh! Sun! you, rising up in the sky and travelling northwards, cure my heart and skin diseases. Sun rays are described here as having

the power to cure heart diseases also.

The next hymn reads as follows:

शुकेषु मे हरिमाणं रोपाणकासु दध्मसि ।

अथो हारिद्रवेषु मे हरिमाणं निदध्मसि ।। *Ṛgveda*, I.50.12.

Oh! Sun God! please give the greenish colour of my diseased body to parrots or green plants.The colour is an attraction and beauty for them. But, for the body, it is ugliness. Here again the medical power of Sun rays is mentioned.

Oṣadhisūkta

One of the famous sūktas of *Ṛgveda* is oṣadhisūkta. *Ṛgveda* X.97 contains 23 hymns that praise the oṣadhis or medical plants.Various thoughts on the patient, disease, doctor and the medicine are seen in those hymns. Ancient Indians believed that all kinds of plants had some medical power. We have story of Jīvaka who was directed to fetch a plant that has no medicinal value. He failed in his mission which hints to the fact that all plants and trees are having some kind of medical value. The oṣadhisūkta in *Ṛgveda* gives some meaningful hints to these aspects:

ओषधीः प्रतिमोदध्वं पुष्पावतीः प्रसूवरीः ।

अश्वा इव सजित्वरी वीरुधः पारयिष्णवः ।। *Ṛgveda X.97.3.*

The medical plants are like horses that take the diseased to the other side of the ocean of torture. They, shining forth with flowers and fruits, cure all diseases.

अन्या वो अन्यामवतु अन्यान्यस्या उपावत ।

तास्सर्वा संविदाना इदं मे प्रावता वचः *Ṛgveda X.97.14*

Let one medical plant reach the other and act for the cure of diseases.Thus the plants, combined together, may help to eradicate all the diseases. Each medical plant has its own power. At the same time, they have a special power when they combine together with others (auṣadhiyoga).The special power of plants when combined together is

also referred to here.

Protection of Forests

Environmentalists are seriously concerned with the protection of forests, by which the balance of nature can be retained. The Ṛgvedic seers also were fully aware of this fact. *Ṛgveda* X.146 praises forests and stresses the need of their protection.There are six hymns in this sūkta which begins as follows:

अरण्यान्यरण्यानि असौ या प्रेव नश्यसि ।

कथा ग्रामन्न पृच्छसि न त्वभीरिव विन्दति ।।

Here the goddess of forest is invoked. She is happy and contented to be in the solitude of the forest. She is not at all afflicted with fear and is happy always. The second hymn in this sūkta reads thus:

वृषा रवाय वदते यदुपावति चिच्चिकः ।

अघारिभिरिव धावयन् अरण्यानिर्महीयते ।।

Different creatures in the forest produce the sound 'ci ci' in the night. Other creatures also produce the same sound imitating them. The goddess of forest, hearing the melody of music, gets delighted. The next hymn also is very important in this context:

उत गाव इवादन्ति उत वेश्मेव दृश्यते ।

उतो अरण्यानिस्सायं शकटीरिव सर्ज्जति ।।

Animals like cows wander freely and confidentially eating grass and leaves in the forest. Bowers shine forth like dwelling places or houses. People from villages who come to the forest for collecting firewood, return in the evening with sufficient pieces of wood in their hands. All these descriptions indicate that the Vedic seers had great concern about the forests and they believed that they should be protected for a peaceful life on earth.

Ṛta and Ṛṇa

The concept of ṛta and ṛṇa is very important in Vedic texts.These concepts are very much related to the balance of the cosmic order. All

Gods are considered as the followers of the cosmic order and so are called ṛtapas (ऋतं पिबन्तिइति). The word ṛta is used in different meanings like truth in general, a settled rule or law, sacred custom, divine law and divine truth. Even Gods do not want this order to be disturbed. This concept speaks of the balance of man, nature and the cosmic order.

Also there are some ṛṇas or debts to Gods, the spirit of dead etc. like देवऋणम् and पितृऋणम्. Man should perform different rites like yāgas to free him from the debts of Gods. He should perform the rites like śrāddha to get freed from पितृऋणम्. He should give water to the trees and plants and food to the birds and animals around his house. All these are for keeping friendship with them and for maintaining the balance between man, animals and other creatures and plants and trees in the nature.

Protest against Violence in Yāgas

The strong protest against violence in yāgas that arose among the Cārvākas, Buddhists and Jains, had many implications in the history of Indian culture and philosophy. They strongly argued against the practice of killing animals in sacrifices. It is to be noted that the Cārvākas ridiculed priests for cutting trees even for sacrificial posts :

वृक्षान् छित्वा तरून् हत्वा कृत्वा रुधिरकर्दमम् ।
यद्येवं गम्यते स्वर्गं नरकं केन गम्यते ।।
(Cārvākadarśana, *Sarvadarśanasaṅgraha*)

If one will reach heaven cutting trees, destroying plants, doing violence and spreading blood and flesh in the sacrifice, who else is qualified to reach the hell. Also they argue:

पशुश्चेन्निहतः स्वर्गं ज्योतिष्टोमे गमिष्यति ।
स्वपिता यजमानेन तत्र कस्मान्न हिंस्यते ।।
(Cārvākadarśana, *Sarvadarśanasaṅgraha)*

If an animal killed in a sacrifice will reach heaven, then why

does not the yajamāna give his own father in sacrifice to ensure heaven for him after death!

Though these references have other contextual importance and implications, the tone throws some light towards their views on ecological awareness also.They believed that killing animals and destroying plants and trees even for the purpose of sacrifice, will cause imbalance in the nature's order.

Observance of Silence

Observance of silence was considered as no less a spiritual activity as compared to the recitation of mantras which involves noise. Hence the student is advised in *Āpastambagṛhyasūtra* to put firewoods into the ritual fire in the evening silently because, by doing so, he becomes favourite to Prajāpati. Many rites in different Gṛhyasūtra are instructed to perform silently. The residuals of the añjana is to be anointed in the eyes of the bridegroom silently in marriage ceremony. Many such rites are advocated in different texts to be performed silently. Similarly, restraining speech after the performance of principal rites is prescribed in connection with upanayana and samāvartana. *Āpastambagṛhyasūtra* states that the student, after adoring himself in the samāvartana, should observe silence till the stars appear in the sky. The vow of silence smong the saints is famous. All sannyāsins used to observe vow of silence for a prescribed period every year. The legend of Śrī Śaṅkara's observance of silence connected with the dramatist Śaktibhadra, is famous. Sound pollution is a difficult problem now faced by all of us. Can we think that the Vedic seers had forseen the consequences of sound pollution and that is why they prescribed the vow of silence also in various rites and rituals! These points are to be further discussed and subjected to deep analysis.



Environmental Awareness in Ancient India

C. Rajendran

Environmental problems have been the focus of attention of the industrialised world ever since the publication of Rachel Curson's *The Silent Spring* (1962), an epoch-making work,which documented the harmful impact of the use of DDT on soil and the living organisms.The earlier belief that the nature could be exploited without any sort of inhibition became thoroughly shattered by this and similar findings, as man gradually came to realise the price he had to pay for the unbridled manipulation of nature. The enlightenment vision of man as posited against nature had to be given up in favour of holistic concept of the cosmos in which man also was a member. Nature no longer remained an inexhaustible resource to be exploited ruthlessly; her forests depleted and water polluted, the very existence of life on earth became problematic. Man became belatedly aware of the inbuilt safety-mechanisms in nature like the green-house effect and problems posed by phenomena like global warming, industrial pollution, depletion of forest wealth, the drying up of rivers and the like. In short, man became more environment conscious. Against this background, ancient cultures like that of India have a pivotal role to play in removing the slop-sided concept of development of the modern man and in offering alternate visions of development and well-being. It has, indeed, been widely acknowledged that it is the relentless vigil of traditional

sects like the Vaishnoi group and Chipko movement, drawing on traditional wisdom,.which have prevented total deforestation in places like Rajasthan and Himachal Pradesh against the exploits of man's greed. If we delve deep into our traditional lore, the depth of the vision of our ancestors about our environment and the care they took to preserve it in tact shall astound us. Here an attempt is made to explore the environmental awareness reflected in Sanskrit literature.

Even in the Vedic era, which represents the dawn of human civilisation, we find a holistic concept of the universe of which man is only a part. The Ṛgvedic poetry shows the early Indian's intimate connection with nature. Most of the Vedic gods are personified forms of natural forces like sun, dawn, thunder, rain, wind and the like. But the most interesting concept in Vedic thought is related to ṛta, which signifies, apart from the moral order of the universe, its physical order as well, consisting of cyclic recurrence of day and night and other natural phenomena.The former somehow is regarded as the basis of latter. The ecological significance of this is its conceptual similarity with the delicately poised order in nature recognised in modern science. Ancient Indians regarded the cosmos as an orderly whole, and considered trees and plants as infested with life. *Mahābhārata* explicitly states that trees have life since they grasp both pleasure and pain and grow if cut.[1]

An interesting hymn in *Ṛgveda* is about araṇyāni, the forest goddess (X.97). The Ṛgvedic poet here describes the weird sights and sounds of the forest at night vividly. Plants are often evoked as divinities, along with waters, rivers, mountains, heaven and earth. One entire hymn in *Ṛgveda* (X.97) is devoted to medical plants (oṣadhi)[2]. The Vedic poets also refer to birds and animals, rivers and mountains, seasonal variations and other facets of nature. We see environmental awareness much more sophisticated in *Atharvaveda* which gives a prominent place to herbal medicine and as such shows amazing awareness of the medicinal value of plants. Actually, *Atharvaveda* advocates a psycho-herbal mode of treatment in that it prefaces the administration of herbal meidcine with the chanting of the appropriate mantra. The diseases mentioned include fever, leprosy, jaundice, dropsy, scrofula, cough, opthalmia, baldness, lack of vital power,

fractures and wounds; the bite of snakes or injurious insects, and poison in general; mania and other ailments[3]. Macdonell describes *Atharvaveda* as the oldest literary monument of Indian medicine.[4]

The Āyurvedic system of herbal medicine, which developed in India's soil, shows the intimate relation between man and nature in ancient India. Āyurveda believes that prevention is better than cure and the best way of prevention of ailments is living close to nature. Accordingly, great importance is given for ṛtucaryā, the 'seasonal regulations' by means of which we come to terms with the concerned season by way of appropriate food, exercise and lifestyle. Suśruta maintains, in this connection, that kāla or time, of which has the year as the body and the seasons the limbs is a major point of consideration in treatment. Of all, six seasons are accepted by Indian authors,viz., śiśira (late winter), vasanta (spring), grīṣma (summer), varṣa (rain), śarat (autumn) and hemanta (early winter). The first three seasons are regarded as seasons belonging to uttarāyaṇa or the northern movement of the sun and human body is supposed to be weak due to this. On the other hand, during the next three seasons,when the sun undergoes the dakṣiṇāyana phase, man is invigorated due to this seasonal movement. Picturesque descriptions are given in works like Vāgbhaṭa's *Aṣṭāṅgahṛdaya* about the various seasons and the change they bring about in the environment. Thus in hemanta, the sky becomes smoky, atmosphere foggy, and the sun less hot. With cold winds blowing, there will be a tingling sensation in teeth and horripilation in body. Beautiful flowers like lodhra, priyaṅgu, punnāga and lavalī surround the earth. Since digestion becomes strong , more sweet/saline/sour food is required. Since a person becomes hungrier in the morning, he should eat heavy breakfast. Massaging and wrestling are suggested to keep the body fit. The same life-style is suggested for śiśira, the late winter also.

In the spring season, which is portrayed very poetically, there is a sudden spurt of flowers and birds as well as bees become vociferous. The phlegmatic humour (kapha) gets aggravated in the body and produces nausea and indigestion. Strong inhalation therapy is prescribed to check this. Exercises and light food, consisting of old barley, wheat, honey as well as the meat of animals dwelling in arid

forests are prescribed. Bathing and use of the pastes of karpūra, candana, aguru and kuṅkuma are some other prescriptions for the spring season.

In summer, since vāyu gets accumulated, one is asked to avoid saline, pungent and sour things, as well as exercises and exposure to sunrays. Sweet food, which is light, unctuous, cold and liquid and diluted corn-flour, sugar, ghee, meat of wild animals, śālī rice, milk, pastries etc. are prescribed. One should avoid alcohol, but can have cold buffalo milk. Walk in dark forests, sprinkling the curtains with cold/fragrant water, and spreading flowers in the bed are some of other tips suggested to fight the heat.

In the rainy season, it is said that there is suppression of the power of digestion because of the heat coming from the earth and the sour change coming over water. One should use moderate diet, resort to fomentation, massage, and sleep in a place free from wind. In order to avoid vāyu and kapha, one should use pungent, sour and alkaline things. Some of the dietary prescriptions include old barley, wheat, śālī rice, meat of forest animals, garllic, old alcohol, curd, etc.

The autumn season (śarat) suddenly exposes one's body, accustomed to rain cold, to the heat of the sun. The pitta humour, accumulated in rain becomes dominant. One is advised to take bitter, sweet and astringent food. Water exposed to the sun during the daytime and the cooling rays of the moon during night is to be used for bath. One should avoid exposure to dew, alkaline foods, curd, oil, animal fat, exposure to the sun, strong alcohol, sleep during daytime and eastern wind.

Āyurvedic texts also refer to perversion of the characteristic features of seasons due to vitiation of land and mention change in colour, touch and smell in the environment due to various reasons. Mention is also made of the excess of flies, insects, mosquitoes and worms. Measures are also prescribed to cope with the epidemics caused by changes in the environment. Even if it may not be possible for us to find a scientific explanation for such prescriptions, the fact remains that ancient Indians were aware of many environmental problems as of today.

Environmental problems are addressed to in works like *Arthaśāstra* also, when dealing with settlement problems and the construction of

new cities. Kauṭilya shows astounding ecological awareness when he maintains that sanctuaries (called abhayavanas) are to be set apart for wild animals[5]. Private parties who come forward to set up a garden or orchard are to be encouraged by the state[6]. The land not used for agricultural purposes is set apart as grazing ground for domestic animals[7]. Kauṭilya refers to three types of forests, viz. those used for hunting (mṛgayā), those for timber and other forest products and those for elephants[8]. There were provisions in the law to punish people hurting animals and capital punishment was accorded to a person killing an elephant[9]. Fine is prescribed for cutting down trees and branches of trees.

Ecological aspects are taken into account in town planning also. Sanitation and water supply are given top priority by Kauṭilya. He maintains that some gap should be maintained between two houses.There should be provision to remove waste water from the buildings. If the drainage system is obstructed by somebody, it invites severe punishment[10]. Kauṭilya has also given astoundingly clear instructions for keeping the stables for horses and elephants clean with proper sanitary arrangements and separate fodder compartments so that food is not contaminated. Further, throwing up dirt and debris on the public road, contaminating public places with urination and disposal of corpses and carcasses of animals etc. are expressly prohibited[11]. Kauṭilya also refers to natural calamities like fire and flood, epidemics, famine and pests and environmental degradation brought about by them and suggests remedial measures also, whenever possible.

Ancient Indians gave utmost importance to environmental engineering when planning settlements or building new houses. According to *Devīpurāṇa,* the first thing to be done is the plantation of trees: the building of the house should follow[12]. According to house construction manuals like *Manuṣyālayacandrikā,* environmental considerations like the nature of the soil, its slopes, flora and the like are to be taken into account before one selects a site for residential construction[13]. The work also prescribes as to which plants are to be planted on different directions of the compound. Plantation of a tree is

regarded as an auspicious deed and cutting down a tree condemned as a sin. According to *Matsyapurāṇa,* a lake is equal to ten walls, a tree is equal to ten lakes, a son is equal to ten lakes and a tree is equal to ten sons.[14] Such pronouncements bring forth the emotional bond Indians had fostered with trees in particular and nature in general. If we go through the works of poets like Kālidāsa,we can find that such gifted authors, apart from accurately documenting the rich biodiversity of the nature around us bring forth the emotional bond between man and nature, a bond which we have broken at our own risk.

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Environmental Activism

P.V. Ramankutty

Ecology, environment, bio-diversity, natural resources, pollution and waste management are terms that are being frequently used in the modern parlance and they have assumed great gravity and significance over the last forty years not because of their conceptual novelty but because they are intimately interlinked with the problem of the survival of humanity on this planet. Ecological awareness or environmental consciousness gained meaningful impetus throughout the world in the 1960-s and ecological and environmental movements constitute one of the significant social movements today. As far as our country is concerned, the core issue that generates environmental problems is the scarcity of prime adequate resources like water, electricity, fuel, home to live as well as conveyance facilities.

The word environment generally means the natural conditions of land, air and water in which humans, animals and plants co-exist. The term is also used to describe rivers, forests and mountains in relation to the life of human beings. Ecology also imbibes the idea of the natural relationships or the study of natural relationships between flora and fauna and the people and the places where they inhabit.

Environmental and ecological consciousness was, naturally, more intense in ancient India where life did not have the complexity it assumed later. Vedic and classical Sanskrit literature depict human situations against the backdrop of the varied scenes of natural beauty. Forests, mountains, valley, streams and rivers appear with their refreshing loveliness and man's existence on earth is pictured to be

one of deep-rooted friendliness with natural phenomena as is evident from the following verse of Bhartṛhari:

> मातर्मेदिनि, तात मारुत, सखे तेजः, सुबन्धो जल,
> भ्रातर्व्योम, निबद्ध एष भवतामन्त्यः प्रणामाञ्जलिः ।
> युष्मत्संगवशोपजातसुकृतस्फारस्फुरन्निर्मल-
> ज्ञानापास्तसमस्तमोहमहिमा लीये परब्रह्मणि ।।

The Gravity of the Situation

Modern man is confronted with a volley of environmental issues that threaten his normal healthy life on earth. Air is getting more and more polluted. Sources of water are getting slowly dried up. Topsoil is getting washed away and the productivity of the soil is declining. Millions are affected by floods, landslide, soil erosion, deforestation and the construction of huge dams and hydel projects. Deforestation, on its part, has adversely affected not only the productivity of the crop-lands but the life of animals, ecological balance and water-resources as well. Construction of huge dams and hydro-electrical projects have caused the displacement of tribals from their traditional homelands. This is yet another problem of serious concern. Overfishing, occupational health and bad resource management are other problems.[1]

The Poor the Worst Affected

The poor are invariably the worst affected. Ecological management is always accompanied by social justice. Displaced from home land, many tribals become strangers in the forest which was once their own. Even if they are given new pieces of land somewhere else, they will be at a loss to pull on since they remain deprived of their roots to survive. Most often the place where they are rehabilitated will be in a distant region and the land will be infertile. The money received as compensation is spent away soon making them orphans in strange land. Moreover, their rehabilitation is carried out in a most arbitrary manner. Alternative proposals are not placed before the displaced poor, nor is their prior consent obtained before they are banished. " 'Land for land' or 'cash for cash' are merely policy mirages, if not outright

fraud; what the poor need is livelihood" - observes L.C. Jain,[2] former member, Planning Board. Even if cash compensation is given on the basis of the most recent land-sale nearby, the poor will spend it on things they like best with the result that by the time the projects are commissioned, they would have become paupers. The displaced poor should be rehabilitated in such a way that their right to live and find a livelihood is protected.[3] Such a practice must be there in the rehabilitation and settlement programme.

The multinational corporations are exploiting the natural resources of third world countries including India and in the process they destroy environment.[4] At the same time they will be clamouring for ecological balance and environmental protection.

Environmental Movements

It is against such a background that environmental movements slowly emerged. They began in the West and over the last forty years they have spread far and wide in the third world countries including India. Environmental struggles are sometimes waged unsuccessfully. One of the arguments often levelled against environmental activism is that it is against the development of the country especially at a time when the country needs rapid industrialisation to counter the problem of unemployment. But the environmental movements are not against the development of the land but against the manner in which the natural resources are destroyed in the name of development.

Significant Initiatives

Some of the significant initiatives in the country on environmental activism are detailed below:[5]

1. Movement against Sardar Sarovar Bhopalpatnam and Inchampalli dams in Madhyapradesh and Maharashtra. The area where the dams are built is inhabited by Gond tribals. The movement is backed by all political parties. It was led by well-known environmentalists like Sundarlal Bahuguna and Baba Amte. Government committees later started assessing the

environmental impact in respect of Bhopalpatnam and Inchampalli dams.
2. The Chipco Movement, initiated by Chandiprasad Bhatt, is against the Vishnuprayag Hydroelectric project. It was feared that the construction of the project would result in the destruction of the unique eco system of the area.
3. Another movement is against the construction of a large dam in Lalpur in Gujarath. It is led by Harivallahab Parikh.
4. V.D. Saklani has started a movement against the construction of Tehri dam, which might result in the submergence of the Tehri town.
5. Movement against the Bedhi Project in Karnataka, which resulted in the abandonment of the project.
6. Struggle against Manibhadra dam proposed to be built in Orissa in one of the prime forest areas.

Numerous struggles were being waged by noted environmentalists like Medha Patkar, Arundhati Roy, Anil Agarwal (passed away in Jan 2002) and a host of other dedicated individuals.

Some of the significant direct actions undertaken by voluntary agencies and individuals deserve mention in this context.[6]

1. The well-known journey for the protection of the Western Ghats. It was undertaken by nearly one hundred and fifty individuals belonging to the States of Kerala, Tamilnadu, Karnataka, Goa and Maharashtra. The volunteers were divided into two groups. Starting on 1st November 1987, they journeyed through 600 villages covering 4000 Kilometres.
2. Journey for the protection of Nilgiri in 1988.
3. Procession undertaken for the protection of Silalikh in Kashmir.
4. Precessions undertaken by environmentalists in Andhra and Orissa for protection of environment lasting for fifty days in1991.
5. The Aravali protection journey in 1993.
6. The Kanyakumari March organized by the Fisher folk Forum in 1989.

The Kerala Scene

Being a thickly populated State whose people have attained a fair degree of literacy, Kerala, over the last four or five decades, has grown into one of the most ecologically conscious regions of the country. Environmental awareness has gone deep into Kerala psyche. An average Keralite is now more conscious of that which surrounds and affects his life. He is now well aware that pollution caused to air, water and earth will adversely affect the natural quality of the environment. His mindset is currently more eco sensitive to make out that a peaceful co-existence of plants, animals and human beings is what is natural and everything else is unnatural.

Kerala's environmental problems can be subsumed under the titles namely, forest, agriculture, irrigation and drainage, aquatic living resources, animal husbandry, urbanisation and housing, mining and quarrying, energy, industry and transportation.[7]

Deforestation has been a problem in Kerala over the last several years. The media has been bringing out several instances of illegal tree felling which adversely affects the eco system of the land especially because forests in Kerala are great centres of biodiversity. This issue is also related to the life of tribals who are thrown out of their homelands for some reason or other. They are presently on the path of agitation over the non-distribution of adequate land to them. Afforestation by planting eco friendly trees and urgent steps to protect the existing 6600 Square Kilometres of forestland are the need of the hour. Problems related to the improper use of available agriculture land, unscientific use of chemical manures and pesticides are also there. The disproportionate nature of the cultivation of cash crops, speedy transformation of agriculture land as house-plots constitute part of the ecological issues of the present day Kerala. So also shortage of drinking water to millions in a land where we get comparatively better rain falls, unscientific water management, mechanised fishing marring the ecological balance of oceans and the day to day life of artisanal fishermen, the slow but steady death of rivers, lakes and other water

places, ruthless kind of sand-mining, continuous dumping of garbage in rivers causing pollution, frequent incidence of drought have been imparting their adverse impact on the life of the land. Industrial development and the subsequent problem of pollution and waste management constitute yet another environmental subject in the State. Stinking cities are a new phenomenon in Kerala. Negative results caused by unplanned urban development constitute another ecological issue.

Unimaginative and uncontrolled development of commercial tourism is causing a number of unexpected ecological and cultural problems in the State. All proposals concerned with tourism need to be discussed at various levels before implementation. The policy document of the Government in relation to tourism says: "All tendencies that destroy our environment and our social and cultural values will be discouraged." But the present scenario in the field of tourism presents a different picture. The need of the hour is to explore the possibility of introducing a kind of integrated eco tourism.

The word transportation brings in a number of unpleasant pictures to our mind. Unprecedented rise in the number of vehicles and poor road conditions have been the causes for the steady increase in the number of road accidents in the State.

The emission of unhealthy gases from vehicles is a subject that is being discussed at various levels. Another issue that throws up a number of problems related to ecology is that of power generation along with which appear the attempts to construct big hydroelectric projects. Mining and quarrying and animal husbandry are also aspects that provoke environment-related problems.

Initiatives of Environmental Activism in Kerala

1. The well-known Silent Valley Movement. The Silent Valley Project had to be abandoned as a result of the movement.
2. People's struggle against pollution caused by Mavoor Gwalior Rayons factory.
3. The NAPAM Movement against the Goshri Project.

4. Churakkund forest protection struggle.
5. Local movement against the Carbide Steel factory in Palakkad.
6. Local movement against mining in Madayippara in Kannur.
7. There are struggles for the protection of all major rivers in Kerala including Nila and Pampa.
8. There are movements almost in all cities against the dumping of waste and subsequent pollution in thickly populated areas.
9. Struggle against the undue utilisation of large quantity of ground water harming the ecological balance of the area by the Coco-cola factory in Plachimada near Palakkad.
10. Movement by environmentalists and inhabitants of Padre village in Kasargod district against the use of Endosulfan, a deadly pesticide which has adversely affected the life of many hapless people in the locality.
11. Movement in Kuttanad, once the granary of Kerala, for the protection of agriculture land.
12. The Vayanad organisation for the protection of nature and against the massive cultivation of trees like Eucaliptus, Acacia etc.

Conclusion

The problems in the country where huge dams are being built or have been built remain unsettled. They continue to haunt the Government as well as the people affected in the area. In some places the hardships experienced by people who are indirectly affected by the construction of huge dams, have been completely neglected by successive governments. The calculated planned utility of certain huge dams is seen considerably reduced when actual utility is put into practice. In such cases, often the area of irrigation and the output of crop will be much less than what was anticipated. Again, in some places where larger dams have been built, studies have brought to light that salination and waterlogging have destroyed vast expanse of croplands. Several experts have begun to question the very usefulness of large irrigation systems. Alternative eco-friendly small-scale projects

have been proposed to be put to use. Indeed environmentalists like Medha Patkar, Arundhati Roy and Anil Agarwal are of the view that big dams are unnecessary and that community based rain-haversting is enough to counter the threat of drought.[8] There is a society for people participation in eco-system management (SOPPECOM) led by R.Datye of Bombay. This organisation has put forward an alternative proposal for Sardar Sarovar dam. The alleged nexus between construction lobby and Government agencies is also being highlighted.

Grass-root level environmental activists are organising get-togethers to share their experiences and to see that a parallel eco-friendly concept of development is introduced in the country. Such a concept and subsequent practice of the same after proper deliberations will be able to protect the environmental or ecological harmony and balance without which humanity cannot survive in the days to come. A special issue of the *Time Magazine* was published in November 1997 solely dedicated to ecology and environment, which highlighted the latest problems in the field and solutions for the same. The magazine sought to emphasise that saving the environment is the biggest challenge that the 21st century has to confront.

Environmental activism for maintaining the natural quality of environment by checking the addition of anything to air, water and land, is to emerge from voluntary groups and agencies formed by people who are ecologically well conscious.[9] They must function irrespective of political affiliations. At the same time they must have a healthy, progressive political commitment, which means a painful consciouness of what we are continuously losing and what is at stake in the present day world. Movements launched by such meaningful attempts by devoted people will bring out remarkable results. When communities assert their right to decide how their resources will be used, Governments are forced to listen, albeit through legal intervention - observes the *Survey of Environment* conducted by *the Hindu* in 1999.

References

1. See Preface to *The Fight for Survival,* Centre for Science &

Environment, New Delhi, 1967.

2. *Down to Earth Magazine,* New Delhi Aug 31, 2002. Another significant publication is the *Citizens Report on the State of Indian Environment,* The Centre for Science and Environment, New Delhi.
3. *Ibid,* Observation made by B.G. Verghese in an article. p.49.
4. *The Fight for Survival,* p.2
5. *Encyclopaedia of Ecology and Environment* by Dr. Priyaranjan Trivedi, Indian Institute of Ecology & Environment, New Delhi, Vol.10.
6. G. Gopinathan Nair's Malayalam translation of *Ecology and Equity* by Madhav Gadgil and Ramachandra Guha, Kerala Sastra Sahitya Parishat, 1995, pp.177-180.
7. The document submitted by Kerala Sastra Sahitya Parishat to the Govt. of Kerala in 1993. pp. 1-58.
8. *The Hindu,* July 13, 2000.
9. Sundarlal Bahuguna in an article written on Kerala observes that most of the environmental groups in Kerala are in cities and they make a lot of noise doing nothing and adds that Kerala also has small groups of serious nature-lovers. See *Jīvitattilekku Maṭaṅṅuka,* Malayalam translation of Sundarlal Bahuguna's book by P.K. Uthaman. Modern Books, Sultan Battery, Nov.2001, p.109.



Arthaśāstra
Scientific and Technical Aspects

P. V. Narayanan

The very term 'Arthaśāstra' primarily refers to a branch of study which had been a prominent part of ancient Indian knowledge. In the present age this term is popularly used to refer to the political treatise authored by Kauṭilya.

Artha in the *Arthaśāstra,* according to Kauṭilya, is the "source of the livelihood of men". The territory of a state and its inhabitants who may follow a variety of occupations come in the range of its meaning (See, *Arthaśāstra,* XV.1.1-2). Artha is also defined as the material well being of the nation and its people (*Ibid,*1.7 6-7) and economically productive activity particularly in agriculture, cattle rearing and trade (*ibid.*1.4.3). These definitions essentially hint at the three objectives of a state. They are, promotion of the welfare of the subjects, possessing of wealth and enlargement of territory. Thus, *Arthaśāstra,* in its broad sense is the science of state craft, which include administration, law and order, justice, taxation, revenue and expenditure, foreign policy, defence and war. In brief, *Arthaśāstra* is the science which gives practical advices to a ruler in connection with the internal as well as external affairs of the state.

Kauṭilya's *Arthaśāstra* is the early extant work on that branch of knowledge. It is evident from his work that Kauṭilya was not the

originator of the science. He himself acknowledges that his work is based on similar treatises composed by earlier teachers. On many occasions he cites the names of his predecessors and quotes their views.

The authorship and date of composition of *Arthaśāstra* has always been a matter of great controversy since its publication. It is accepted here that *Arthaśāstra* was originally composed by Kauṭilya alias Viṣṇugupta also popularly known as Cāṇakya, in the Mauryan period, ie. between the end of the fourth century and the beginning of the third century B.C[1].

Arthaśāstra, though is mainly concerned with the statecraft, it deals with all the aspects related to state administration. According to Kauṭilya, the main source of the power of a state is treasury. The existence and development of a state rely up on the strength of its economy. And, the economic prosperity of a nation, as is well known, depends upon its manufacturing industries, agriculture, mineral resources and trade. Besides, the security of a state and the life of people are highly dependent on the planning and building of cities, forts, palaces and such other structures. *Arthaśāstra* gives considerable space to discuss on such topics. Thus, a detailed discussion on science and technology therein becomes imperative.

Arthaśāstra is written in the style of the early sūtra-works. It is mostly written in prose interspersed with a few verses. For convenience of analysis the work is divided into 15 adhikaraṇas. It may generally be said, the work deals with two areas which constitute the science.They are tantra and āvāpa. Tantra which means the internal administration of the state, is described in first five adhikaraṇas and āvāpa, i.e the acquisition of others' territory and relation with neighbouring states, is dealt with in the next eight (6-13) adhikaraṇas. Adhikaraṇas 14 and 15 are miscellaneous in character.[2]

Kauṭilya who believes "hindrance to science brings destruction" gives valuable information on scientific and technical aspects pertaining to agriculture, animal husbandry, architecture, mining and metallurgy, metrology of weight, length, volume and time, coinage, gemmology,

weaponry, liquor manufacture, textile industry and so on. In short, a number of scientific and technological subjects have been treated in *Arthaśāstra* on par with the science of law and administration. A general survey of such topics dealt with in *Arthaśāstra* is made here.

Agriculture

Arthaśāstra is the earliest available literary source which gives elaborate description about agricultural practices prevalent in early India.The work provides copious information on agriculture in chapter 11.24. In the administrative set up envisaged in *Arthaśāstra,* there was a distinct department to look into the affairs of agriculture. The head of this department was known as *sītādhyakṣa*- Superintendent of Agriculture. *Sītādhyakṣa* was expected to be conversant with the practices of agriculture such as suitability of soil, ploughing, preparation of land and selection of proper seeds, water divining and the science of rearing plants on one hand and the amount of rainfall that was expected to occur in different seasons of the year on the other.

Agriculture was the most important state activity. Kauṭilya is of opinion that "cultivable land is better than mines, mines fill only the treasury while agricultural production fills both the treasury and the store house." The land according to their nature was divided into different categories, as kṛṣṭa (ploughed or cultivated), akṛṣṭa (uncultivated), sthala (ground), kedāra (wet-field), ārāma (parks), ṣaṇḍa (vegetable gardens), vāṭa (sugarcane plantations) and mūlavāpa (field for the cultivation of roots). Another division in accordance with the geographical and climatic conditions is also seen. They are jāṅgala and ānūpa. Of these, jāṅgala is dry land and *ānūpa* is wet land. In classifying the fields for agriculture, regional differences and characteristics also had been given due attention. Aśmaka (Maharashtra region), Avantī (Malva region), Aparānta (Konkan region) and Haimānya (regions near by Himalaya or snowy regions) are the areas thus referred to in *Arthaśāstra.*

A large number of crops were cultivated in different seasons. Śālī and vrīhī are two varieties of rice. Godhūma (wheat), yava

(barley), kodrava (Paspalum scrobicalatum), varaka (Phaseolus trilobus) and priyaṅgu (millet) are other cereals specified. Lentils and beans include mudga (Phaseolus mungo), māṣa (Phaseolus radiatus) śaimbya, udāraka and kulattha (Dolicus biflorus), tila, kusumbha (Crocus sativas) kalāya and sarṣapa (mustard) are the oil seeds recommended for cultivation. Vegetables and edible roots also are referred to. Besides, several perfumery plants, medical herbs like uśīra (Vetiveria ziznioides) hrībera and piṇḍāluka (Trewia mdiflora?) and different kinds of spices are enumerated. In addition to this, reference to long pepper, sugarcane, seed of pulses, plantain etc also can be seen there.

Arthaśāstra testifies to the fact that the farmers had the knowledge of corporation (11.24). It recommends three crops in a year with crop rotation. Kauṭilya specifies the land suitable for every crop. Sowing of crop was determined in accordance with the availability of water, nature of land and season. Seeds are prepared accordingly. Numerous methods for the treatment of different seeds and plants are described in it. Plant protection was given proper attention. Reference to fertilizers to be applied to the seeds prior to sowing and after the formation of seedlings is available in *Arthaśāstra*. Some mixtures which serve the purpose of germicide are also mentioned. Details of rain fall and harvesting are also described.

Irrigation

Arthaśāstra mentions very many aspects of irrigation. Abundant reference to dams and canals and management of canal water including levying tax etc. are found in various chapters in *Arthaśāstra*. Different methods were employed for irrigating crops. In addition to manually activated irrigation , animals and machines also were used. The work clearly mentions a srotoyantra, which may be understood as a mechanism for transporting water from one level to another, which will be brought through channels to the fields. Unfortunately, neither the text nor any other contemporary source gives information about such mechanism.The taxation of irrigation administration depicted in *Arthaśāstra* remained almost the same in

India till the British period. Thus, it can be said that the information provided in the text clearly is an indication to the existence of a well-developed agricultural system.

Animal Husbandry

A vast amount of knowledge regarding various types of animals belonging to different species is furnished in *Arthaśāstra*. The topics dealt with in it include the regulations for the protection of wild life, punishment for cruelty to animals, food-rations for domesticated animals, breeding of animals, regulation on grazing, responsibility of veterinary physicians, construction of sheds and stables etc. Four chapters in the work exclusively deal with animals. Three separate officials were appointed to look into the matters related to animals. They are godhyakṣa, aśvādhyakṣa and hastyadhyakṣa. Reference to many wild animals also are seen.

Cattle-rearing was a prominent economic activity of the state. Kauṭilya advises to keep regular accounting for animals. Milk was the main product served by cattle. Wool of sheep and goat was another animal product.The meat of cattle was used as food, subject to certain restrictions. Products such as skin, teeth, hooves and horn also were the aim of cattle rearing.

Breeding of domesticated animals was also thought of. Kauṭilya recommends the ratio of male and female animals with regard to breeding. Great attention was paid to horses and elephants, as they were war animals. Description of treatment of horses in their confinement, routine of elephants, characteristics of best horses and elephants, capturing and training of elephants, setting up of sanctuaries etc are available.

A large number of rules and regulations are laid down by Kauṭilya for the protection of animals. Hurting, killing, inciting killing etc of animals were considered as grave crimes. Capital punishment was given to those who kill elephant. Kauṭilya furnishes a long list of cruelties against animals and different punishments suggested to them. Regulations for the protection of wild life, responsibility of veterinary

doctors, control on slaughter etc. are some other topics dealt with. It is noteworthy that the torture of even those animals which are permitted to be slaughtered was strictly prohibited. Slaughter of young and female animals and castration of male animals were restricted. Some species of birds and small animals were declared as protected ones.

Architecture

Arthaśāstra deals with architecture in seven chapters.Technical details of forts, fortified city, town planning and military and residential buildings have been described. Right from the selection of site upto the plastering of wall for safety are discussed in detail. Kauṭilya in this context defines vāstu scientifically: "gṛham kṣetramārāmaḥ setubandhastaṭākamādhāro vā vāstu". As per this, any kind of structure and its engineering can be called vāstu. The work provides highly technical details of construction of parikhā (moat) and wall for the protection of the fort. Various structures such as secret chambers for defending advancing enemy, watch tower to be erected on the fort-wall also are described. Precautions to be employed for protection from fire, hidden passages for escaping during the hour of danger, outlets for water, devices for strengthening doors etc. are furnished.

Details of laying out of the fortified city are significant. Different types of highways, roads and small-paths to be constructed in city are described. Architectural details of construction of royal palace with many enclosures and sectors explained in *Arthaśāstra* are enough to amaze even an expert. Apart from this, foundation of base-camp and building of stables, different types of work shops, garden, ware-house, prison, store-house for forest produces and construction process of treasury with strong and secret arrangements have also been delineated in *Arthaśāstra* from highly technical view point.

Kauṭilya speaks of the residential houses of common people also. He lays down many rules and regulations to be maintained during and after the construction of popular houses. They include, the distance to be observed from neighbour's boundary, minimum gap between the walls of two houses where people used to reside together in communes,

things to be considered while fixing windows, conditions for constructing temporary structure in the compound and drainage facilities to be provided for waste water and rain water. The rules and regulations referred to in *Arthaśāstra* have very much resemblance with current municipal laws in general.

Mining and Metallurgy

The economic prosperity of a country mainly depends upon its mineral resources and manufacturing industry. This fact was realised well by Kauṭilya. He says , "the treasury has its source in the mines; from the treasury the army comes into being; with the treasury and the army the earth is obtained with the treasury as its ornaments" (11.12.37). The chapter II.12 in *Arthaśāstra* is exclusively devoted to describe this topic. Descriptions of mines, ores of different metals, extraction processes, methods of purification, hardening and softening of metals, making of alloys, transmutation of metals, manufacture of ornaments of complex nature with precious metals etc. are given.

According to *Arthaśāstra* the 'mines' constitute "gold, silver, diamonds, gems, pearls, corals, conch-shells, metals, salt and ores derived from the earth rocks and liquids" (II.12). The authority of all works connected with mining was khanyadhyakṣa - Director of mines. He must be a person well-versed in the science of metallic-veins in the ground, metallurgy, alchemy and smelting and also an expert in the art of colouring gems (II.12 and *Bhāṣākauṭalīya,* part II, P.113). The mining wing was manned by several skilled workmen and also equipped with necessary apparatus..

The prospecting work of mining was conducted in old mines as well as in new ones. Means of inspection and recognition of old mines are given in the text. Although production would be comparatively less, the mining in old mines might have been profitable as the investment was less. Mines were categorised on the basis of their nature. They were functioned in hill-areas, on banks of rivers and forests. The informant of mine was rewarded with one-sixth part of the income from such mine.

Gold, silver, copper, lead, tin and iron were the metallic ores

mined. Another ore called vaikṛntaka was also referred to in *Arthaśāstra*. But, it has not been identified yet. The nature and characteristic of each ore is described. Kauṭilya advises various chemical processes for the extraction and purification of ores. One of the techniques of treatment of golden ore called "flotation process" referred to in *Arthaśāstra* is employed even today by metallurgists.[3]

A detailed description of numerous works on gold and silver such as plating, embedding, fixing stones etc. is given in *Arthaśāstra* in two chapters. The means of pilfering and adulteration practiced by goldsmiths and silversmiths during the course of manufacturing and testing of articles are explained. Different varieties of touch-stones are mentioned. Several alloys of gold and silver, gold and copper, silver and copper, copper and iron etc. are described. The ratio of combination is also specified. Ārakūṭa (brass), vṛtta (sheet), kamsa (bronze) and tāla (bell-metal) are the popular alloys. Besides, tripuṭaka (copper and silver), śvetatāra (gold and silver), veilaka (silver and iron) are mentioned. Liquids extracted from plants, urine and excreta of animals and natural alkalies had been used for different metallurgical processes. Smelting of metals and different types of crucibles, objects to be added for softening and hardening of metals etc. require deep interrogation.

Gemmology

Arthaśāstra II.11 deals with precious stones like gem. The place of origin of different gems, their characteristics, identification of original items, manufacturing of various types of ornaments with them etc. have been discussed. Diamond (vajra), pearls (mauktika), gem (maṇi) and coral (*pravāla*) are the precious stones dealt with in *Arthaśāstra*. A large number of subsidiary types of gems are also named. Reference to artificial gems too occurs in it. As in the case of other branches of knowledge *Arthaśāstra* is the earliest available work on lapidary.

Coinage

The state was the sole authority of minting coins. All the works

right from manufacture upto ensuring effective circulation of currency were carried out by two dignitaries named lakṣaṇādhyakṣa (Director of Mints) and rūpadarśaka (Coin Examiner). Coins of silver and copper were in vogue. No clear reference to gold coin is found in the *Arthaśāstra*. Iron and lead had been used as hardening agents. Different denominations were minted observing different proportions of prime metal and hardener. Silver coin was known as paṇa. It had four denominations - one paṇa,1/2 *paṇa*,1/4 paṇa and 1/8 paṇa. Copper too had four denominations.They are maṣaka, half maṣaka, kākaṇī and half kākaṇī. The value was varied on the basis of the amount of hardening sustenance. The highest one paṇa and lowest half kākaṇī had a difference of 1:128.

The name lakṣaṇādhyakṣa is considered as a reference to the existence of punch-marked coins. The Coin Examiner was the authority to regulate the coinage. Counterfeiting of currency was a great headache for the state. Heavy punishment was given for counterfeiting of coins. In case of detection of counterfeiting the manufacturer was banished away from the country. If any spurious coin was found, it was cut into pieces with a view to prevent it from getting into circulation again.The instruments for minting coins are stated by Kauṭilya, though the actual process of minting is not explained.

Weaponry

Arthaśāstra sets apart a whole chapter to describe the ordinance required for army. The officer in charge of armoury was known as āyudhāgārādhyakṣa. Weapons are divided into eight sub groups according to their nature and use. Numerous varieties of arms were there in each of those categories. They are generally classified into two types as mechanical weapons and common arms. Mechanical weapons are mentioned by the terms sthitayantra and calayantra. Yantra generally means a machine or mechanical contrivance. Sthitayantras are fixed-machines and calayantras are weapons based on mobile mechanism. Use, purpose and form of each weapon are narrated by Kauṭilya. Along with the common arms like bow, arrow, sword, and

spike some varieties of weapons which could be thrown to enemies from a certain distance are also described. Besides, description of armours, shields and other accoutrements for war also is found in *Arthaśāstra.*

Mensuration

Chapters II. 19 and 20 deal with weights and measures. The authority that was responsible for standardisation of weights and measures was called pautavādhyakṣa (Superintendent of Standardisation). Another authority known as mānādhyakṣa was concerned with the measurement of space and time. Many different units were used for linear measures, weights, area measures and volume measures. Description of measurement of time shows very much affinity with astronomical systems. Kauṭilya gives details of manufacture of different weighing and measuring instruments. Regular inspection and stamping of instruments and articles used in weighing and measuring are explained by him. It would be clear from a close observation that the Kauṭilyan metrology was based on sophisticated methods of mensuration.

Textile Industry

Cotton, silk, wool and jute were the raw materials for making clothes. Dyeing of clothe was practiced. Sūtrādhyakṣa was the official posted to look into the affairs related to textile production. Spinning work was mostly done by women and weaving by men. Wage for the work was calculated on the basis of the amount of product manufactured.

Liquors

A whole chapter is devoted to discuss the liquor industry.The manufacture of alcoholic liquor was predominantly a state monopoly. Specific exceptions were, however, provided for physicians making various ariṣṭas, alcohol-based medicines and liquor-like fermented fruit juices. Medaka from rice, prasanna from barley-flour, āsava from sugarcane juice, maireya from jaggery and madhu from grape juice were the important alcoholic beverages. Ariṣṭas were made for medicinal purposes. Different varieties of liquors were manufactured.

The basic types were sāra and kiṇva. They were made by fermenting bean-pulps. Spices and fruit juices were used for flavouring them. Some other items were made with wood-apple or bark mixed with jaggery or honey. Wine from grape was also manufactured. Sahakārasurā was the liquor made from mango. Surādhyakṣa (Chief controller of alcoholic beverages) was responsible for all affairs in this regard.

Preparatrion of Documents

Documents, letters and edicts play a crucial role in administration. Kauṭilya enumerates the characteristics of various documents, their types, defects etc. in II. 10. The royal scribe was known as śāsanādhyakṣa. He was expected to have thorough knowledge of all conventions, be quick in composition, and have good handwriting and must be able to clearly read documents and edicts. Topical order, non-contraction, completeness, sweetness, dignity and lucidity are the main features of good document. Different types of documents such as informatory, commands, awards, exemptions, authorisation, guidance and response proclamations are described by Kauṭilya. The manner of preparing a document also is mentioned as a valuable source in the study of science and technology in early India, particularly during the age of Mauryas.

References

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2. An exhaustive table of contents discussed in each adhikaraṇa is given in the beginning of *Arthaśāstra.*
3. Mrinalini Sapotdar, "Ancient and Medieval Metal Technology in India" in G.Kuppuram and K. Kumudamani (Eds.) *History of Science and Technology in India,* Sandeep Prakashan, New Delhi, 1990.



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